Draft Technical Evaluation

NEW BEDFORD

301 (h) APPLICATION

September, 1981

TETRA TECH, INC.

Site: NEW BEDFORD
Break: 17.7
Other: ______

TECHNICAL EVALUATION OF CITY OF NEW BEDFORD WASTEWATER TREATMENT PLANT SECTION 301(h) APPLICATION FOR MODIFICATION OF REQUIREMENTS FOR DISCHARGE INTO MARINE WATERS

DRAFT

by

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for

U.S. Environmental Protection Agency

September, 1981

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PART A

PART A - GENERAL

Section 1. Description of Treatment System

The application submitted by the city of New Bedford for modification of secondary treatment requirements is based upon an improved discharge. The proposed improvement for the existing primary treatment plant consists of an extended outfall with a diffuser.

Existing Treatment System--

Figure 1 indicates the location of the New Bedford plant. The New Bedford treatment plant serves an area with a population of approximately 101,000 people. The wastewater collection system includes both combined (60 percent) and separate (40 percent) sewers and receives residential and industrial sewage. Approximately 22 percent of the influent is expected from industrial sources by 1988. The applicant does not present detailed flow data in this section such as dry- and wet-weather flows. The average flow for 1979 is identified as 1.05 m^3/sec (24 MGD). The projected average flow for 1988 is 1.29 m^3/sec (29.4 MGD). The plant design capacity is given as 1.31 m^3/sec (30 MGD).

During dry weather, the wastewater influent receives primary treatment. The unit processes at the plant include grit collection; bar screens; primary sedimentation; chlorination; and sludge degritters, thickeners, and centrifuges. During wet weather, excessive storm-related wastewater is

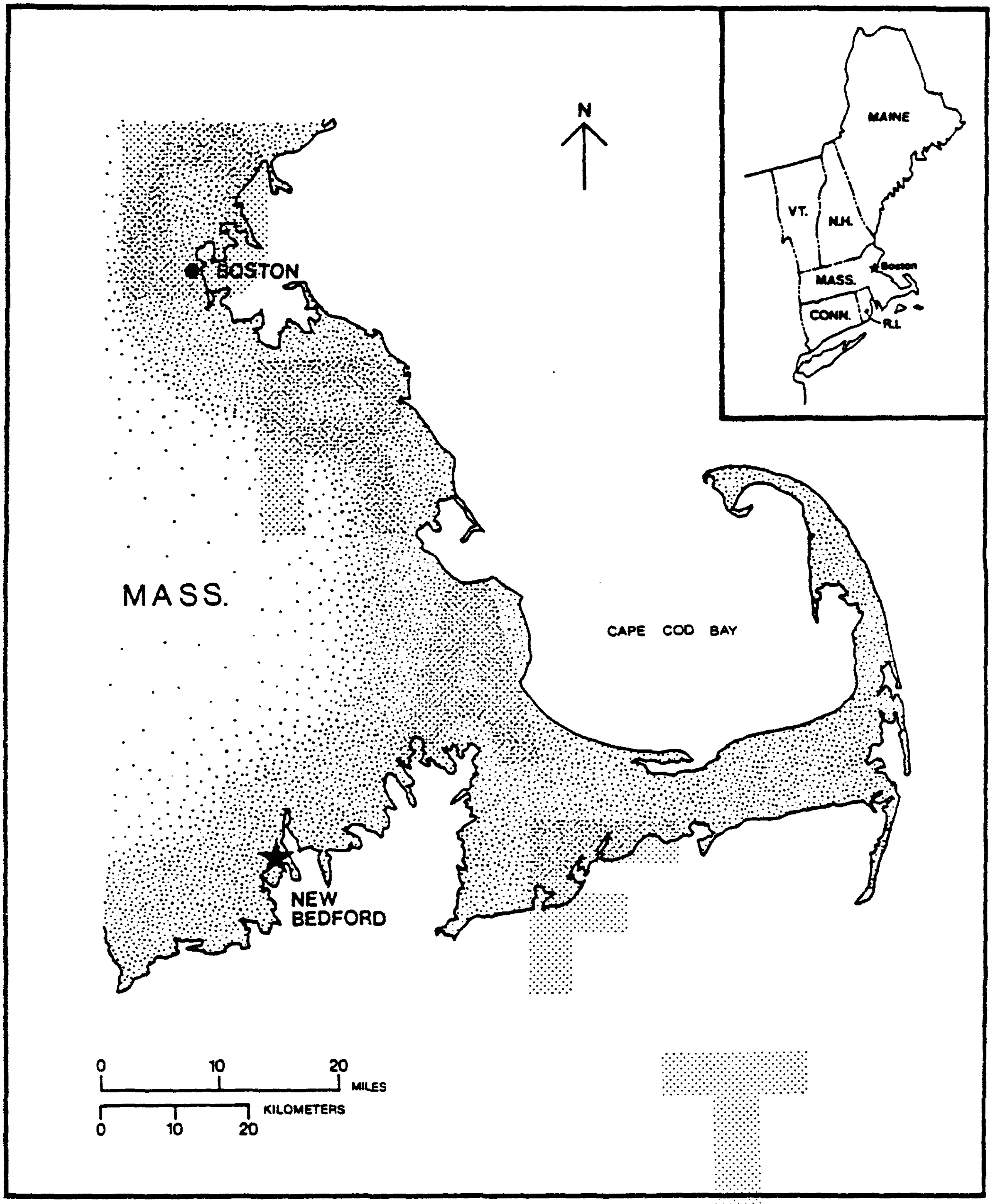


Figure 1. General location of the New Bedford, MA, treatment plant.

simply chlorinated and discharged through a separate outfall. Sludge from the primary sedimentation tanks has the grit removed (and discharged to a landfill) and is then thickened and dewatered. The supernatant is recycled to the wet well. The dewatered sludge is incinerated and the ash disposed of in a landfill.

Existing Outfall--

The existing marine outfalls and the proposed extended outfall and diffuser are shown in Figure 2. The existing outfall for the dry-weather flow consists of a 1.52-m (60-in) diameter pipe which extends about 1,006 m (3,300 ft) out into Buzzards Bay. The outfall ends in a single outfall port which is a 90^{0} cast iron elbow encased in concrete and rip-rap at a depth of 8.8 m (29 ft) below mean sea level. Excess storm flow is discharged through a 1.83-m (72-in) diameter pipe which extends about 305 m (1,000 ft) into Buzzards Bay to a depth of 7.3 m (24 ft). The applicant does not provide any discussion concerning the distribution of effluent flows between the two outfalls. Discharge monitoring reports for 1979 - 1980 also do not indicate the frequency of use of the emergency outfall nor the flows discharged.

Proposed Improvements--

The proposed system modification involves usage of a single 1.83-m (72-in) outfall. Plans are to utilize the existing storm flow outfall, extending the pipe and adding a diffuser. The improved outfall would extend 6.7 km (22,000 ft) further into Buzzards Bay with a 250-m (820-ft) diffuser.

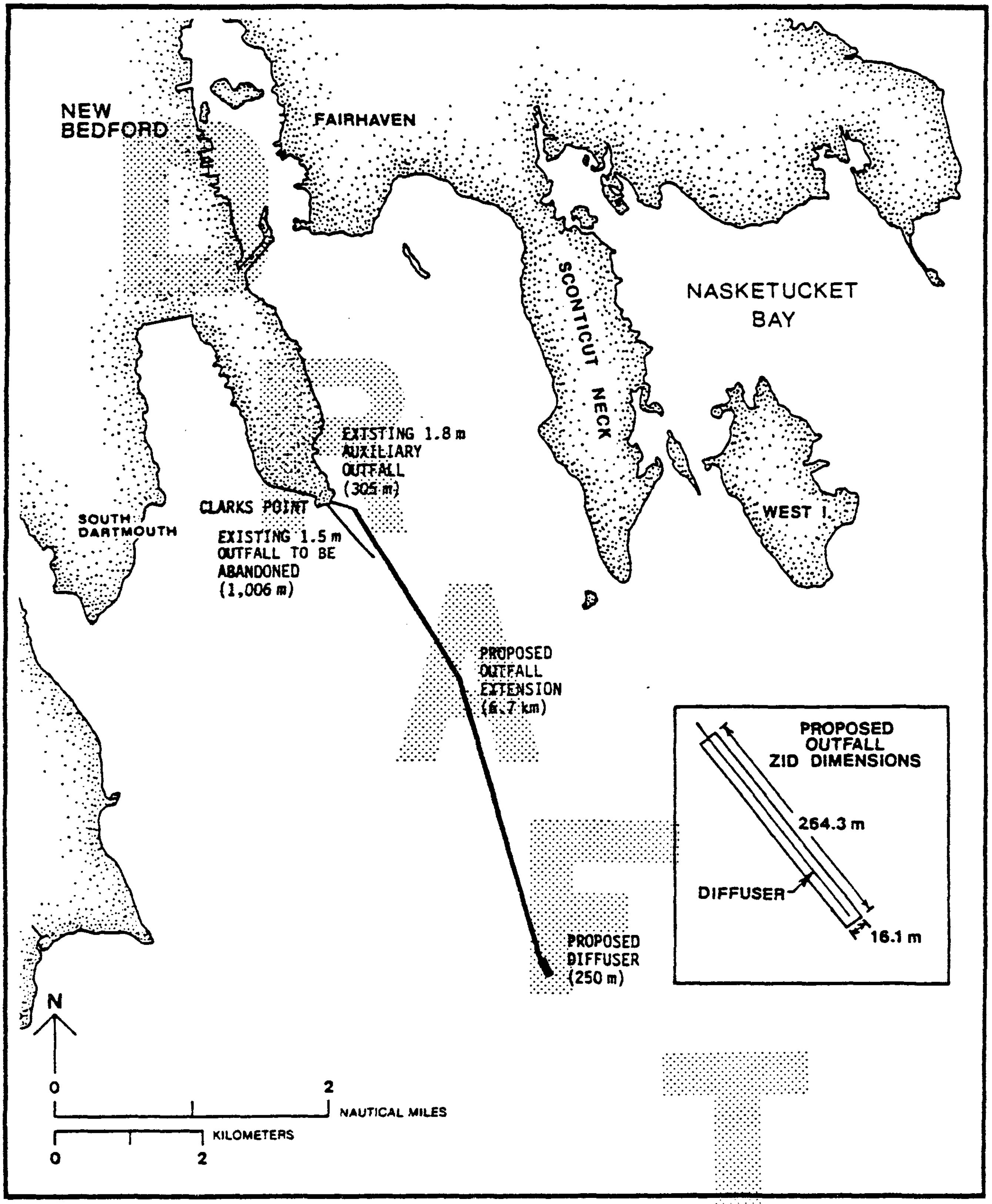


Figure 2. Location of existing and proposed outfalls for the New Bedford, MA, treatment plant.

The preliminary design calls for a multi-port diffuser with 186 staggered ports, each having a diameter of 10 cm (4 in). The diffuser would be located in about 13.7 m (45 ft) of water, with the final alignment dependent on the local bathymetry.

The applicant is planning treatment system improvements to assure proper and efficient operation. Preliminary recommendations have been identified; however, complete Step 1 planning documents will not be finalized until 1981. The initial recommendations include:

- New aerated grit removal facilities
- New sludge pumping station and tunnel
- Additional sludge handling systems
- Grease and scum removal improvements
- Modify sludge dewatering system
- Additional incinerator
- New sludge storage tank
- Modify chlorination system.

These will be subject to revision in the final facilities planning report documents. As of the completion of this evaluation report, Step 1 planning documents have not been provided to EPA.

Section 2. Effluent Limitations

The city of New Bedford's application for a modification is based upon the following final effluent limitations:

Parameter	Annual Average
Biochemical oxygen demand	97 mg/l
Suspended solids	50 mg/l
pH	6.0 to 9.0

Raw wastewater values for 1979 presented by the applicant indicate an influent BOD of 134 mg/l and suspended solids of 98 mg/l. Projected annual average influent values for 1988 are 138 mg/l for BOD and 100 mg/l for suspended solids. Based on the final effluent limitations, expected removal efficiencies through the permit period would be 30 percent for BOD and 50 percent for suspended solids.

Section 3. Existing Discharge

The New Bedford primary treatment plant began discharging to marine waters in January, 1974. The location of the discharge into Buzzards Bay is 41^{o} 35' 7" N latitude and 70^{o} 53' 37" W longitude.

Section 4. State Secondary Treatment Requirements

There is no state requirement for secondary treatment of coastal or marine discharges. Primary treatment plus disinfection is the minimum treatment requirement according to the Massachusetts water quality standards. The applicant does cite from the state water quality standards that "minimum treatment requirements will be increased where necessary to satisfy other state and federal laws and regulations or to achieve the water quality assigned in these regulations, whichever is the most stringent."

Section 5. State Coastal Zone Management Program

The modified discharge will be located in an area which is under jurisdiction of the Commonwealth of Massachusetts Regulations on Ocean Sanctuaries, which has been approved under the Coastal Zone Management Act of 1972. The Department of Environmental Management has confirmed this in a letter received by the applicant on August 30, 1979.

Section 6. Marine and Estuarine Sanctuaries

The modified discharge is not located in a marine or estuarine sanctuary designated under Title III of the Marine Protection, Research, and Sanctuaries Act of 1972, as amended, or under the Coastal Zone Management Act of 1972. This has been confirmed by a letter dated August 11, 1980, from the National Oceanic and Atmospheric Administration (NOAA).

Section 7. Endangered or Threatened Species

The applicant identifies the following nine endangered or threatened species that may possibly inhabit or obtain nutrients from the waters affected by the proposed discharge:

Common Name	Scientific Name
Shortnose sturgeon	*Acipenser brevirostrum*
Blue whale	*Balaenoptera musculus*
Bowhead whale	*Balaena mysticetus*
Finback whale	*Balaenoptera physalus*
Gray whale	*Eschrichtius robustus*
Humpback whale	*Megaptera novaeangliae*
Right whale	*Eubalaena* spp. (all species)
Sei whale	*Balaenoptera borealis*
Sperm whale	*Physeter catodon*

Because the exposure to the effluent would only be brief, if at all, no deleterious effects on these species is expected. The discharge is not in an area designated as a critical habitat.

<u>Section 8. Other Applicable Federal Requirements</u>

The applicant is unaware of any other federal laws applicable to the discharge.

<u>Section 9. Existence and Compliance with State Water Quality Standards</u>

State Water Quality Standards--

The Commonwealth of Massachusetts has designated the waters which receive the New Bedford treatment plant discharge as Class SA. Waters assigned to this class are used for the protection and propagation of fish, other aquatic life, and wildlife; for primary and secondary contact recreation; and for shellfish harvesting without depurvation in approved areas. Minimum water quality requirements and the specific criteria for Class SA waters are presented in Table 1.

Compliance with Water Quality Standards--

The applicant refers to Part B, Sections 2-5 for evidence that the discharge will comply with water quality standards. Certification that the discharge will meet the state requirements has been requested from the

TABLE 1. COMMONWEALTH OF MASSACHUSETTS
WATER QUALITY STANDARDS

Minimum Criteria

The following minimum criteria are adopted and shall be applicable to all waters of the Commonwealth, unless criteria specified for individual classes are more stringent.

Parameter	Criteria
1. Aesthetics	All waters shall be free from pollutants in concentrations or combinations that: a) Settle to form objectionable deposits; b) Float as debris, scum, or other matter to form nuisances; c) Produce objectionable odor, color, taste, or turbidity; or d) Result in the dominance of nuisance species.
2. Radioactive Substances	Shall not exceed the recommended limits of the United States Environmental Protection Agency's National Drinking Water Regulations.
3. Tainting Substances	Shall not be in concentrations or combinations that produce undesirable flavors in the edible portions of aquatic organisms.
4. Color, Turbidity, Total Suspended Solids	Shall not be in concentrations or combinations that would exceed the recommended limits on the most sensitive receiving water use.
5. Oil and Grease	The water surface shall be free from floating oils, grease and petrochemicals, and any concentrations or combinations in the water column or sediments that are aesthetically objectionable or deleterious to the biota are prohibited. For oil and grease of petroleum origin the maximum allowable discharge concentration is 15 mg/l.
6. Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.
7. Other Constituents	Waters shall be free from pollutants in concentrations or combinations that:

TABLE 1. (Continued).

	a) Exceed the recommended limits on the most sensitive receiving water use; b) Injure, are toxic to, or produce adverse physiological or behavioral responses in humans or aquatic life; or c) Exceed site-specific safe exposure levels determined by bioassay using sensitive resident species.

Additional Criteria

The following additional minimum criteria are applicable to coastal and marine waters for Class SA waters.

Parameter	Criteria
1. Dissolved Oxygen	Shall be a minimum of 6.0 mg/l.
2. Temperature	None except where the increase will not exceed the recommended limits on the most sensitive water use.
3. pH	Shall be in the range of 6.5-8.5 standard units and not more than 0.2 units outside of the naturally occurring range.
4. Total Coliform Bacteria	Shall not exceed a median value of 70 MPN per 100 ml and not more than 10% of the samples shall exceed 230 MPN per 100 ml in any monthly sampling period.

Division of Water Pollution Control. The state has initially responded that further review of the application is necessary.

State Mixing Zone Policy--

The applicant does not discuss the mixing zone policy for Massachusetts in this section of the application.

The Massachusetts' regulations concerning mixing zones are:

"Regulation 2.2 Mixing Zones. In applying these standards [water quality standards], the Division may recognize, where appropriate, a limited mixing zone or zone of initial dilution on a case-by-case basis. The location, size and shape of these zones shall provide for the maximum protection of aquatic resources. At a minimum, mixing zones must:

a) Meet the criteria for aesthetics;

b) Be limited to an area or volume that will minimize interference with the designated uses or established community of aquatic life in the segment;

c) Allow an appropriate zone of passage for migrating fish and other organisms; and

d) Not result in substances accumulating in sediments, aquatic life or food chains to exceed known or predicted safe exposure levels for the health of humans or aquatic life."

Section 10. Improved Discharge Construction

Evidence of Thorough Planning and Study--

The applicant's proposed improvements appear to be thoroughly planned, based largely on a 1974 report on "Wastewater Collection System and Treatment Facilities."

Evidence of Financial and Technical Resources--

The applicant refers to statements in the transmittal letter as evidence of financial and technical resources. However, the transmittal letter contains no details of either financial or technical resources which may be available.

History of NPDES Permit Compliance--

The applicant presents limited, general information concerning NPDES permit compliance. The applicant states that "The City of New Bedford has met all realistic dates cited in the 1974 NPDES Permit." This implies not all NPDES dates have been met; however, details of any non-compliance are not provided.

Schedule for Secondary Treatment/Proposed Improvements--

The schedules in Table 2 were prepared by the applicant to demonstrate the timing for staged planning, design, and construction of secondary treatment or less-than-secondary treatment. However, some of the dates indicated have not been met, including the June, 1981, dates for final submittal of the facilities plan. As of the completion of this evaluation report, no Step 1 document has been provided to EPA.

TABLE 2. SCHEDULES FOR SECONDARY AND LESS-THAN-SECONDARY TREATMENT[a]

		(A) Schedule for Secondary Treatment		(B) Schedule for Implementation of Modified Discharge	
		Estimated Date	Months Between Events	Estimated Date	Months Between Events
1.	Step 1 grant start date	May, 1979	-	--	-
2.	Start Pilot Plant testing for secondary treatment	September, 1979	4	--	-
3.	Preliminary report and EAS on siting for secondary treatment	March, 1980	6	--	-
4.	Complete Pilot Plant testing	March, 1980	6	--	-
5.	Final submittal of facilities plan; submit Step 2 grant application	June, 1981[b]	15	June, 1981	c
6.	Start Step 2 design	January, 1982	7	January, 1982	7
7.	Final plans and specifications completed and approved by EPA and state	September, 1983	20	April, 1983	15
8.	Execute construction contract for secondary treatment facilities	February, 1984	5	September, 1983	5
9.	Complete secondary facilities or primary facilities with modified outfall placed in operation	August, 1987	42 (3.5 years)	March, 1986	30 (2.5 years)
10.	Full operation level attained	February, 1988	6	September, 1986	6

[a] Discussed among state and CDM on August 30, 1979, and September 6, 1979.

[b] The Facilities Planning report will be complete June, 1980, and the combined Sewer Overflow (CSO) study and Step 2 Grant will be finished June, 1981 (neither date has been met by the applicant) as of the completion of this evaluation report.

[c] Predicated on primary treatment being considered a viable alternative in an amended Step 1 - Cost Effect Analysis.

PART B

PART B - TECHNICAL EVALUATION INFORMATION

Section 1. Physical Assessment

Outfall Diffuser System--

The New Bedford treatment plant has two existing outfalls. Presently all dry-weather wastewater flows are given primary treatment and then discharged through the existing 60-in outfall; excessive storm-related flows are chlorinated and discharged through the existing 72-in outfall. The existing 60-in outfall is a 1,006-m (3,300-ft) long pipe which terminates in a single horizontal discharge port. The 72-in outfall is a 305-m (1,000-ft) long pipe and also terminates in a single horizontal discharge port.

The New Bedford application is predicated on the construction of an improved outfall/diffuser system. The proposed discharge site is located approximately 7.0 km (23,000 ft) offshore of Clarks Point in Buzzards Bay. The applicant states that the actual alignment of the proposed outfall and the diffuser configuration will be finalized when detailed ocean bathymetry and soils data have been obtained and evaluated. The locations of the existing and proposed outfalls are shown in Figure 3 (applicant's Figure A-1).

The proposed outfall will be an extension of the existing 72-in outfall and will terminate in a 250-m (820-ft) multiport diffuser. The 60-in outfall will be retired. Most of the applicant's physical assessment

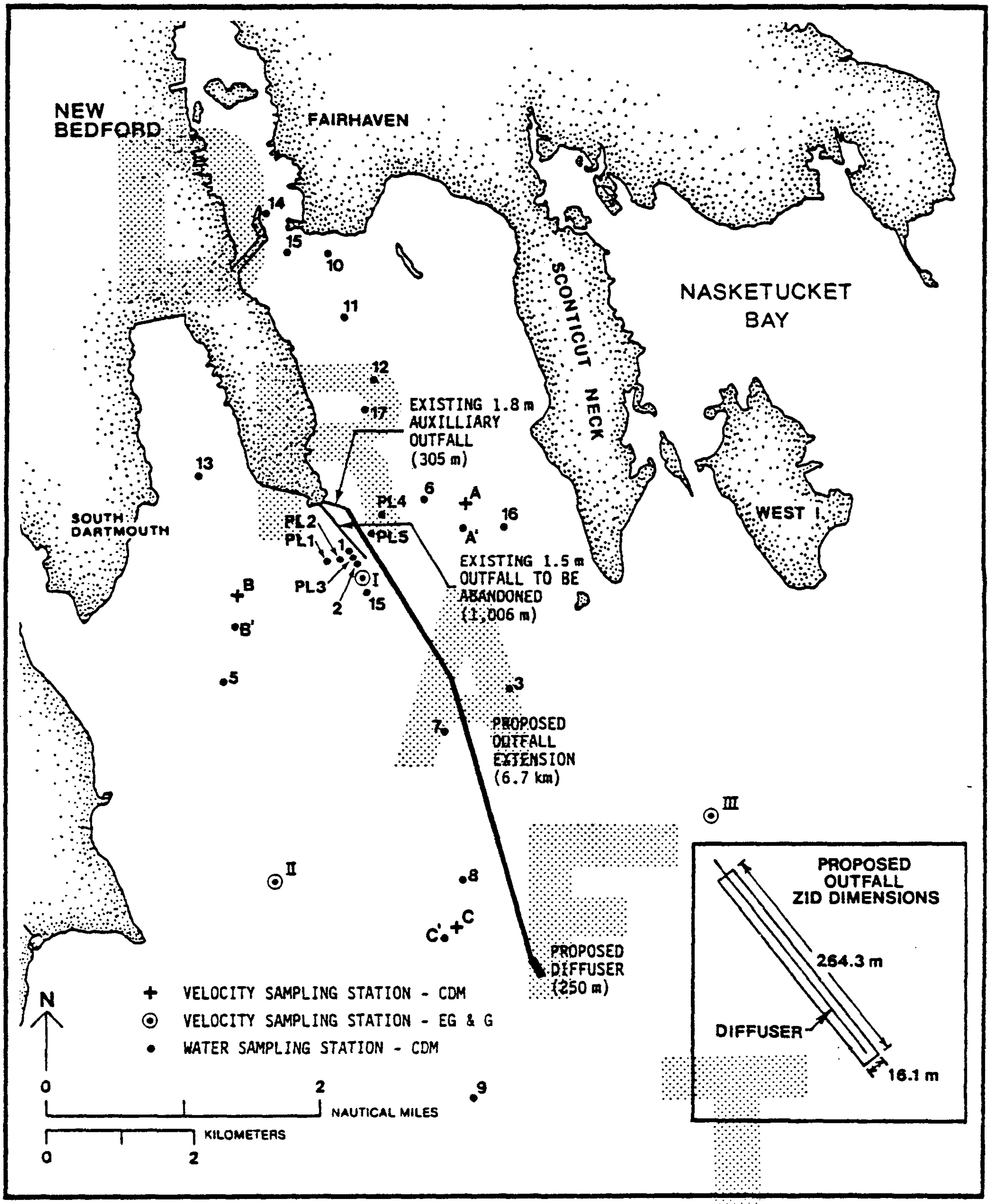


Figure 3. Locations of outfalls and sampling stations, New Bedford, MA.

considers the proposed outfall rather than the existing outfalls. The same emphasis is reflected in this review. The physical characteristics of the proposed diffuser are listed in Table 3. The diffuser is shown schematically in Figure 4 (applicant's Figure A-6). The design flow rate as calculated from the design port flow rate is equal to 3.162 m^3/sec (72.17 MGD).

As part of the review procedure, the proposed diffuser is evaluated for adequacy of design. The existing outfalls are simple and require no analyses. Evaluation of the proposed diffuser includes analysis of the hydraulic behavior of the diffuser and whether or not the diffuser is likely to achieve reasonable dilutions.

The hydraulic characteristics of a well-designed ocean diffuser are discussed in several sources, among them Rawn, Bowerman, and Brooks (1961), and more recently, Grace (1978), and Fischer, List, Koh, Imberger, and Brooks (1979). Generally, the most important of these features are:

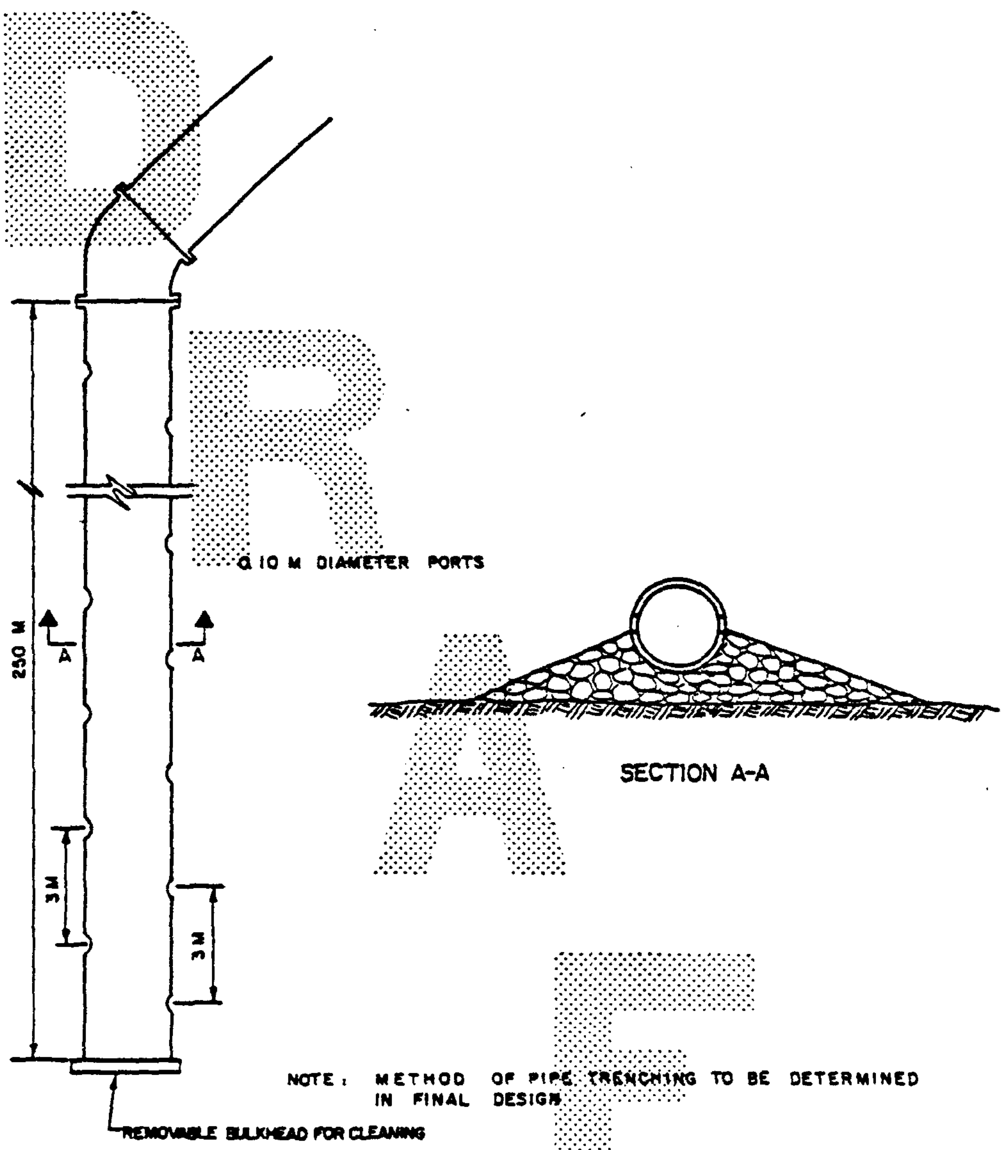
- Fairly uniform diffuser port flow
- For each port, the densimetric Froude number, F_e, of the discharge plume should be greater than one to insure that there is no salt water intrusion into the diffuser pipe.

  where:

TABLE 3. PHYSICAL CHARACTERISTICS OF PROPOSED NEW BEDFORD DIFFUSER

Port orientation (angle in degrees from horizontal)	0^{o}
Port diameter	0.102 m (4.00 in)
Water depth above ports	13.7 m (45 ft)[a]
Density of effluent	0.996 gm/cm^3 @ 18.3° C
Number of ports	186
Port spacing (between centerline of staggered ports)	1.5 m (4.9 ft)
Design port discharge	0.017 m^3/sec (0.397 MGD)

[a] The applicant indicates a 15-m vertical distance between the water surface and outfall port centerline in Section B-1-A. However, the depths shown and both the applicant's Figure A-3, and on DKHPLM runs indicate a depth of 13.7 m, which is used in this evaluation.



REFERENCE: FIGURE A-6, NEW BEDFORD 301(h) APPLICATION, 1979

Figure 4. Preliminary design of proposed diffuser, New Bedford, MA.

$$F_e = \frac{u_e}{\sqrt{g'd}}$$

u_e = port discharge velocity

d = port diameter

$$g' = g\left(\frac{\rho_a - \rho_e}{\rho_e}\right)$$

g = acceleration due to gravity

ρ_a = seawater density at the discharge depth

ρ_e = effluent density

- *Velocity in the diffuser pipe should be greater than 0.6 - 0.9 m/sec (2 - 3 ft/sec) for average flow conditions*

- The total area of ports located downstream of a diffuser section should not exceed one-half to two-thirds of the cross sectional area of that section.

As part of this review procedure, the flow distribution in the proposed diffuser is calculated using a diffuser hydraulics computer program. For this program, friction in the diffuser pipe is expressed in terms of a Manning's n value. Since the applicant does not provide a coefficient of friction for the diffuser pipe or a port discharge coefficient, the flow distribution in the diffuser is calculated for values of Manning's n in the range 0.010 - 0.016. The resulting port discharges are most uniform for a value of Manning's n equal to 0.012; therefore, a value of 0.012 is assumed. The diffuser ports are assumed to be bellmouthed, and the port discharge coefficient is given by:

$$C_D\ (J) = 0.975\ (1-J)^{0.375}$$

where:

$J = V^2/2gE$

V = flow velocity in the diffuser pipe at a given port

g = acceleration due to gravity

E = specific energy of a given port

The slope of the diffuser is also required for evaluation of the flow distribution along the diffuser. As mentioned, detailed bathymetry of the area is not yet available; therefore, the diffuser is assumed to be horizontal. Examination of NOS Chart 12320 of Buzzards Bay indicates that the ocean floor is relatively level at the proposed discharge site. Generally, as the slope of an ocean sewage diffuser increases, the variation in port discharge also increases. If bathymetric studies of the discharge site indicate that the diffuser will not be horizontal, the hydraulic characteristics of the diffuser must be reevaluated.

For the present diffuser design, port flows are uniform. Variation between the minimum and maximum port discharges is less than 2 percent for the design flow rate and the highest 2- to 3-h flow rates reported in Part B, Section 1.2 of the application.

The port densimetric Froude numbers are greater than one for the design and highest 2- to 3-h flow rates. For the design flow rate, velocities in the seaward half of the diffuser are below 0.6 - 0.9 m/sec (2-3 ft/sec). However, a removable bulkhead at the seaward end of the diffuser is indicated on the schematic drawing of the diffuser (see Figure 4). Occasional removal of the bulkhead should preclude problems due to possible sediment accumulation. The ratio of total port area to the area of the diffuser is 0.58.

The proposed New Bedford diffuser meets the important design criteria listed earlier. Therefore, the hydraulic design of the diffuser appears to be acceptable.

In order to investigate whether the proposed New Bedford diffuser is likely to achieve reasonable initial dilutions, it is compared to diffusers of other ocean outfalls. The effluent flow rate considered is the design flow rate of 3.162 m^3/sec (72.17 MGD). Comparisons of various hydraulic parameters are shown in Table 4. As indicated in this table, the port Froude numbers and energy ratios calculated for the design flow rate are slightly below the range reported for other outfalls. The remaining hydraulic parameters compare well with those of other outfalls.

The densimetric Froude number represents the ratio of port discharge speed to effluent buoyancy. As this ratio increases, the immediate initial mixing achieved also increases. The densimetric Froude numbers calculated for the design flow rate indicate that the plume will have less initial momentum and therefore the initial mixing will be slightly less, in a comparative sense, than that of other outfalls. The energy ratio behaves in

TABLE 4. DISCHARGE CHARACTERISTICS, PROPOSED NEW BEDFORD DIFFUSER

		New Bedford[a]	Other Outfalls
Densimetric Froude number	F_o	13	15-30[b]
Depth/port diameter	h/d_o	147	100-700[b]
Depth/port spacing	h/l	10	2-75[b]
Energy ratio	B_o	11-12	15-20[b]
Total port area/pipe area	area factor	0.58	0.44-0.63[c]
Design flow rate/diffuser length	Q/L	0.013	0.009-0.038

$F_o = U_o/(g_o' d_o)^{1/2}$

U_o = port discharge velocity

$g_o' = g \dfrac{\rho_a - \rho_e}{\rho_e}$

g = acceleration due to gravity

ρ_a = seawater density at discharge depth

ρ_e = effluent density

d_o = port diameter

h = water depth

l = port spacing

$B_o = (h/d_o)/F_o$

Q = total effluent flow rate

L = diffuser length

[a] Discharge characteristics calculated using a design flow rate of 3.162 m^3/sec (72.17 MGD).

[b] Grace (1978).

[c] Fischer et al., 1979.

the same manner as the ratio of the potential to kinetic energy of the discharge plume. As this ratio increases, the port flow is more plume-like and as this ratio decreases the port flow is more jet-like. The energy ratio computed for the design flow rate indicates that the plume will be more jet-like. The effect of a more jet-like port flow is to entrain more water at the port depth. In a stably stratified environment this makes the plume heavier than if it were more plume like and may somewhat reduce the overall dilution achieved. The actual initial dilutions achieved are discussed in a later section of this review.

Flow Rates--

The applicant states that the maximum flow rate representing the highest 2 h during an average day is presently 2.018 m^3/sec (46.06 MGD) and is expected to be 2.022 m^3/sec (46.15 MGD) at the end of the permit term. The design flow is 3.162 m^3/sec (72.17 MGD). Other flows are used in the water quality sections of the application. The minimum and average flows are said to be equal 0.483 m^3/sec (11.02 MGD) and 1.097 m^3/sec (25.04 MGD), respectively. No supporting evidence is presented. These flow rates are assumed to be correct as stated.

Ambient Density Gradients--

The regulations request the applicant to identify each of the following critical environmental situations.

- Period of maximum hydraulic loading from the wastewater facility
- Periods of low background water quality due to natural conditions including low DO, excessively high and low turbidity
- Period of exceptional biological activity
- Period of low net circulation, low effective net flushing or low intertidal mixing
- Periods of minimum and maximum stratification.

In Appendix I of the application a brief discussion of the critical environmental situations is presented. The applicant contends that all critical situations occur during the summer except for the period of minimum stratification. Arguments for these conclusions are very brief and sometimes nonexistent. However, the applicant's conclusions appear to be correct.

The regulations request that the applicant provide ambient density gradient lines for the region of the outfall diffuser for each of the critical seasons discussed above. Either worst-case stratification conditions or lowest 10 percentile stratification conditions should be used for initial dilution computations. The applicant states that this question is interpreted as requiring a "worst case" density profile developed from actual data measured in the discharge areas for use in the subsequent initial dilution analyses. The applicant then presents actual density vs. depth data for the present and proposed discharge areas and from these a single "worst case" density profile is developed and used to compute a lowest dilution. This approach is valid assuming the "worst case" profile does indeed give the lowest (or lowest 10 percentile) dilution.

The applicant bases the arguments on the (implicit) premise that highest linear stratification from the bottom to the water's surface represents the critical density profile. Temperature and salinity data from the areas shown in Figure 5 (applicant's Figure B-1) are used. Figure 6 (applicant's Figure B-2) shows the annual monthly cycle of top and bottom temperature and salinity at the Boston Lightship. From this figure, it is evident that the annual salinity variation is approximately 1.7 ppt while the annual temperature varies from 2^{o} to 18^{o} C. Table 5 (applicant's Table B-2) gives a numerical tabulation of the cycles on the previous figure along with the corresponding densities. The maximum density difference between top and bottom is 2.25 sigma units measured during the month of July. Assuming these measurements are applicable directly to the proposed outfall site for New Bedford, this difference corresponds to a density gradient of 0.15 sigma units/m (0.05 sigma units/ft). The applicant also reviews data gathered at the outfall areas during the summer of 1979 and a historical compilation of data on New Bedford Harbor (Ellis et al., 1977). Table 6 (applicant's Table B-3) shows seasonal surface and bottom density data for New Bedford Harbor obtained from these sources.

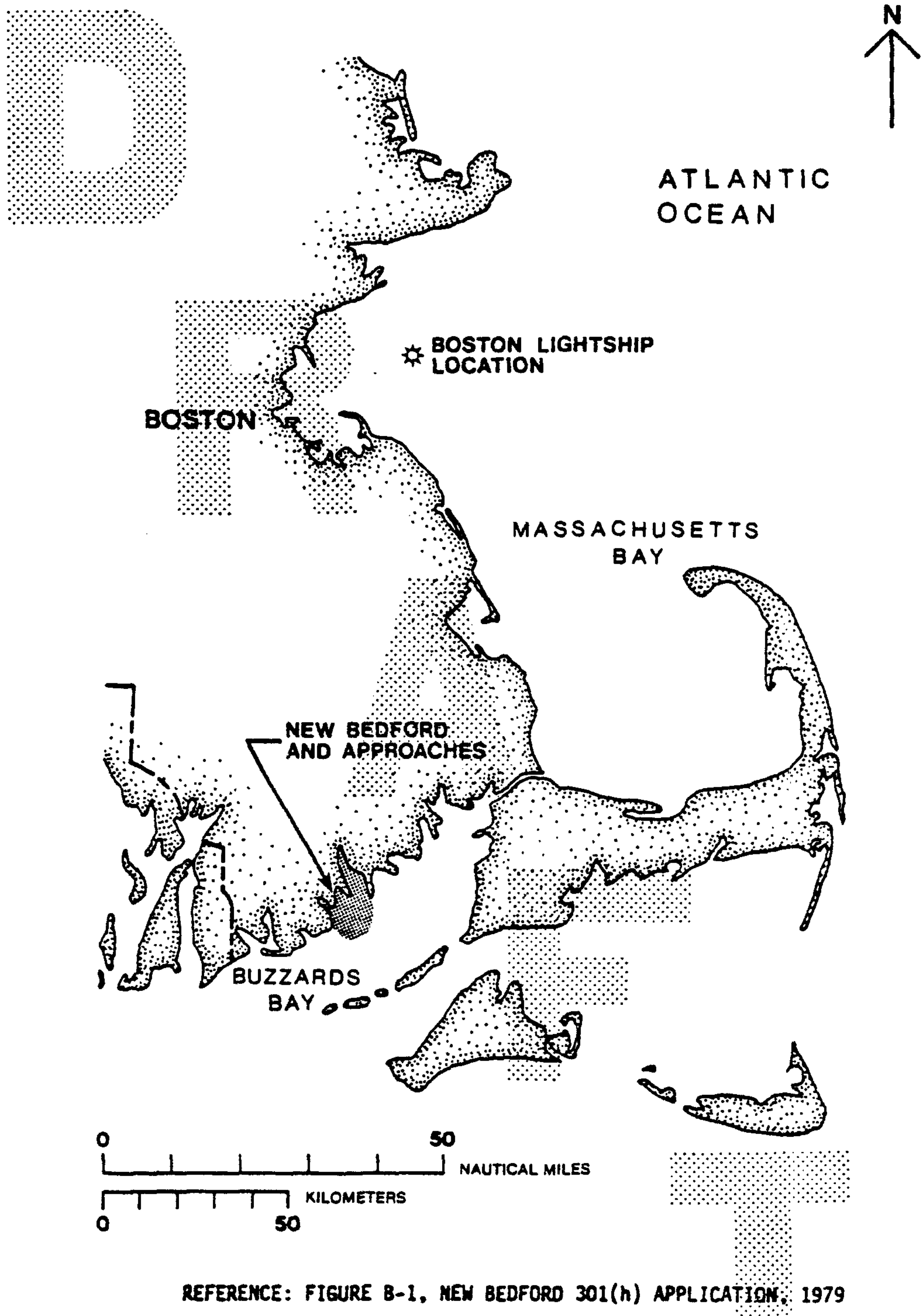


Figure 5. Location of New Bedford Harbor, MA, and areas from which data were explicitly examined.

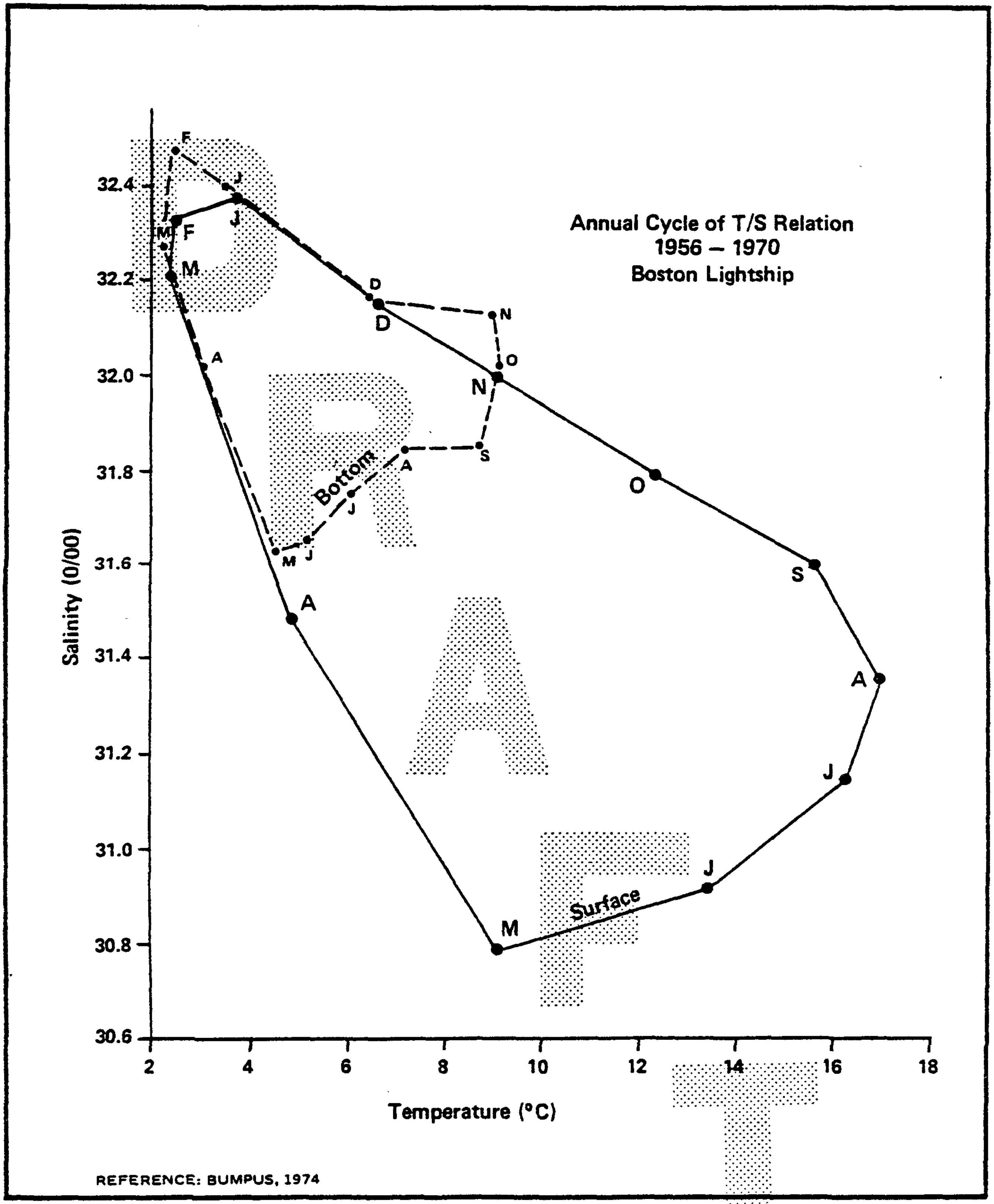


Figure 6. Illustration of annual salinity/temperature in Massachusetts Bay (New Bedford, MA).

TABLE 5. SURFACE AND BOTTOM SALINITY, TEMPERATURE, AND DENSITY DATA FOR BOSTON LIGHTSHIP

	Bottom		Surface		Density[c]		
Month	Salinity[a]	Temp[b]	Salinity	Temp	Bottom	Surface	Difference
Jan	32.40	3.7	32.38	3.9	25.773	25.738	0.035
Feb	32.47	2.5	32.33	2.6	25.933	25.813	0.120
Mar	32.28	2.3	32.21	2.4	25.797	25.733	0.064
Apr	32.02	3.2	31.48	4.8	25.516	24.934	0.217
May	31.63	4.6	30.79[d]	9.2[d]	25.073	23.822[d]	1.251[d]
June	31.66	5.2	30.92	13.5	25.033	23.163	1.870
July	31.75	6.1	31.15	16.3	24.999	22.748	2.251
Aug	31.85	7.2	31.37	17.0	24.937	22.756	2.181
Sep	31.85	8.8	31.61	15.7	24.708	23.233	1.475
Oct	32.01	9.2	31.79	12.3	24.771	24.066	0.705
Nov	32.12	9.1	31.99	9.2	24.873	24.756	0.117
Dec	32.16[d]	6.5	32.15	6.7	25.275[d]	25.239	0.036[d]

[a] Units of ppt.

[b] Units of °C.

[c] Units of σ_t [i.e., $\sigma_t = (\rho-1) \times 1000$].

[d] Correct value, original table in application in error.

Reference: Bumpus 1974.

TABLE 6. SURFACE AND BOTTOM DENSITY DATA FOR NEW BEDFORD HARBOR

Season	Bottom (10 m ± depth) Salinity ppt	Bottom Temperature °C	Bottom Density Sigma t Units	Surface Salinity ppt	Surface Temperature °C	Surface Density Sigma t Units[a]	Δ Density Sigma t Units
Winter[b]	28.30	2.00	22.642	30.00	1.20	21.834	0.8
(January 6, 7)	30.20	1.70	24.177	30.00	1.20	24.046	0.1
Spring[b]	31.10	8.75	24.133[c]	30.80	9.50	23.781	0.1
(April 28, 29, 30)	30.80	8.75	23.898[c]	30.50	9.75	23.508	0.2
	30.80	9.00	23.858	30.80	10.00	23.702	0.2
Summer[d]	31.86	22.00	21.9[c]	31.34	25.93	20.3	3.5
(July 28, 31)	31.99	20.58	22.3	31.68	23.76	21.2	1.1
	32.42	21.52	22.4	31.88	25.66	20.8	1.6
	31.60	23.10	21.3	31.20	26.17	20.1	1.2
(August 17)	33.00	20.50	23.1	32.62	23.84	21.9	1.2
	32.90	22.08	22.6	32.64	26.08	21.1	1.4
Autumn[b]	30.60	9.50	23.625	30.50	9.50	23.548	0.1
(November 26)	30.60	9.25	23.664	30.00	8.90	23.250	0.4

[a] $\sigma_t = (\rho - 1) \times 10$ where ρ = density (g/cc).

[b] From Ellis et al., 1977.

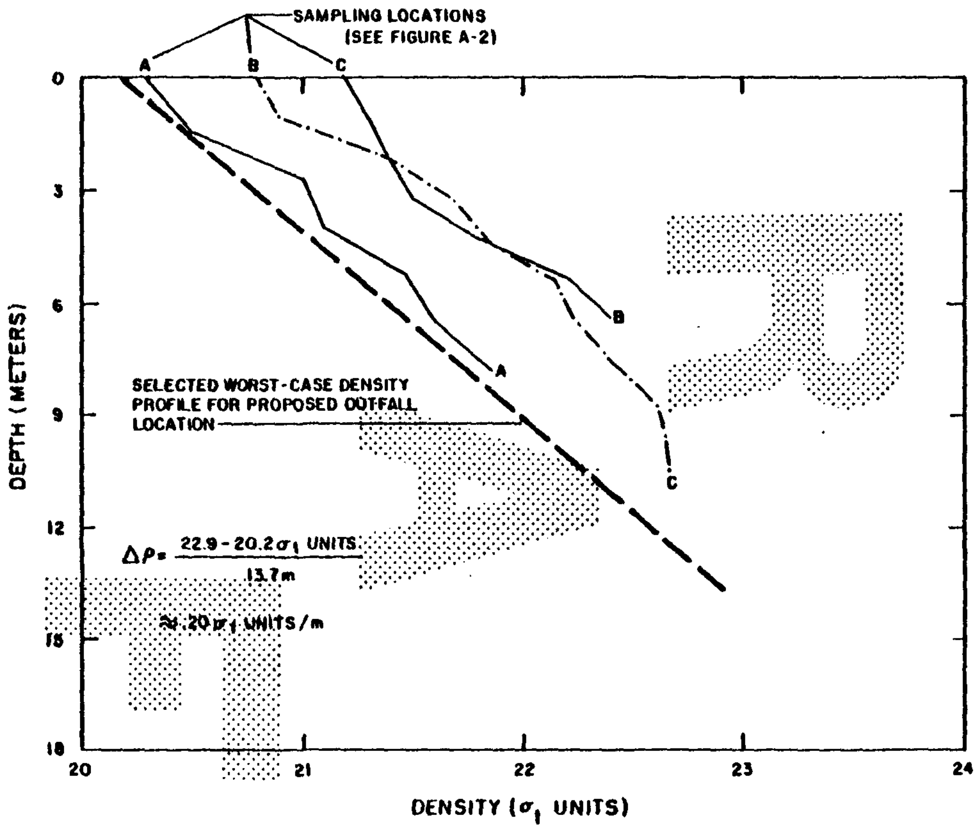
[c] Correct value, original value in error (from application).

[d] By CDM (Appendix III).

The applicant states that "based on all of the data reviewed, it appears safe to assume that the summer corresponds to the period of maximum stratification in the area of New Bedford Harbor. The site specific data collection effort sponsored by the city of New Bedford was, therefore, focused on the summertime conditions." This appears to be appropriate.

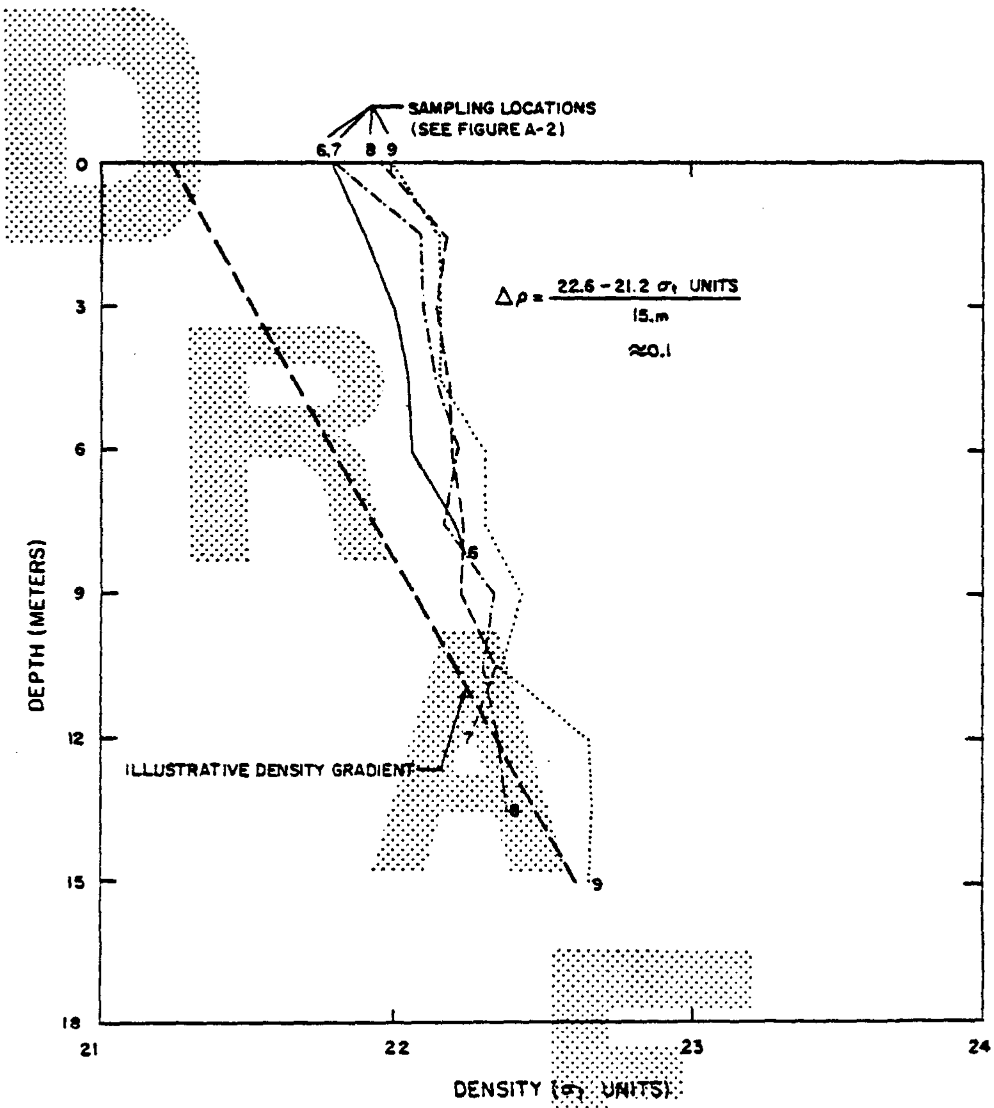
The applicant states that the density gradients measured in the outfall areas during late July exhibit more severe stratification than gradients measured in mid-August. Figures 7 and 8 (applicant's Figures B3 and B4) show some of the most stratified profiles measured and the selected "worst case" profiles for July and August, respectively. From these figures it is evident that the late July profiles are more stratified than those measured in late August. The applicant states that during late July, 1979, the weather was unusually hot and calm. The applicant contends that this type of weather pattern during summer is likely to produce "worst case" density conditions and thus explains the differences in the July and August profiles. This appears to be reasonable.

As part of this review, initial dilutions are computed for the profiles closest to the site of the proposed diffuser and the applicant's critical July and August profiles using a total effluent flow equal to 2.018 m^3/sec (46.06 MGD). The EPA computer model PLUME is used because the DKHPLM model is limited to linear ambient temperature and salinity gradients. As shown in Table 7, the lowest dilution predicted is associated with the applicant's worst-case July profile, which is considered critical.



REFERENCE: FIGURE B-3, NEW BEDFORD 301(h) APPLICATION, 1979

Figure 7. Density profiles as recorded on July 28, 1979, New Bedford, MA.



REFERENCE: FIGURE B-4, NEW BEDFORD 301(h) APPLICATION, 1979

Figure 8. Density profiles as recorded on August 17, 1979, New Bedford, MA.

TABLE 7. INITIAL DILUTIONS PREDICTED USING THE MODEL PLUME WITH THE TOTAL EFFLUENT FLOW OF 2.018 m^3/sec (46.06 MGD)

Profile Date and Station	Initial Dilution	Trapping Level[a] m	Trapping Level[a] ft
July 28, 1979, Station C'	101	7.7	25.3
August 17, 1979, Station 8	260	1.5	4.9
August 17, 1979, Station 9	230	1.2	3.9
July worst case	86	8.2	26.9
August worst case	129	6.2	20.3

[a] Trapping level expressed as depth below the surface.

The DKHPLM computer run for this profile and effluent flow (which is discussed in the next subsection) shows that the plume is trapped 4.7 m (15.4 ft) above the discharge depth for this case. This height is equivalent to a depth of 9.0 m (29.5 ft) below the water surface. Since the sharp decrease in density for almost all of the measured profiles occurs at a more shallow depth, the applicant's artificial profile is conservative. If, however, density profiles having a strong thermocline which occurs at depths greater than about 9.0 m (29.5 ft) were found, then these profiles might give lower initial dilutions. Profile 9, which is shown on Figure 8, is not sufficiently stratified at a depth near 12 m (39 ft) to trap the plume at that depth. The only seasons during which this might occur are late summer or early fall.

Initial Dilution--

The applicant computes a single critical initial dilution for the proposed outfall using the EPA computer model DKHPLM. A computer printout showing the input data and the results is given. The critical average initial dilution is reported to be 76 to 1.

The DKHPLM computation is strongly dependent on the ambient density stratification, the port effluent discharge flow, and the ambient current speed. As noted in the previous subsection, the applicant's density profile is conservative. The discharge velocity used converts to a total effluent flow of 2.2 m^3/sec (50 MGD). This flow is higher than either the present or estimated end of permit term maximum 2-h flows and is conservative since higher effluent flows give lower initial dilutions. [The actual critical flow equals 2.018 m^3/sec (46.06 MGD).] The ambient 10-percent current speed is estimated from current meter data collected at six stations in the area of the existing and proposed outfalls (see Figure 3). Statistical summaries of the data are presented in Apendix IV of the application. The lowest 10 percentile current speeds for all six locations are shown in Table 8 (from page B-16 of the application). Station C is located in over 12 m (40 ft) of water near the proposed discharge site. The statistical summaries at Station C show that speeds in excess of 3 cm/sec (0.14 ft/sec) occur over 90 percent of the time at this location. Therefore, the applicant selects a current speed equal to 3 cm/sec (0.14 ft/sec) for the initial dilution computation. This is a conservative choice based on the applicant's sources. A review computation based on the 1980 tidal current tables (NOS 1979) indicates that current speeds exceed 3 cm/sec (0.14 ft/sec) 95 percent of the time at NOS Station 1150 (1 mi southeast of West Island) in Buzzards Bay. Therefore the "worst case" conditions that the applicant uses to compute the critical initial dilution appear to be conservative.

The initial dilution that the applicant reports, 76 to 1, is the dilution calculated for the maximum height of rise of the plume for a total effluent flow of 2.2 m^3/sec (50 MGD). This is not technically correct because in cases of no current or a weak current, the plume does not continue to entrain ambient water throughout its rise. As a plume rises in the water column it will reach a level at which the density of the plume equals the density of the ambient water. The plume will rise past this

TABLE 8. SUMMARY OF THE LOWEST 10 PERCENTILE CURRENT SPEEDS MEASURED AT THE OUTFALL AREAS

Station	Lowest 10 Percent Speed
A	2.06 cm/sec
B	2.7 cm/sec
C (near surface)	4.7 cm/sec
C (near bottom)	4.6 cm/sec
I (near surface)	1.57 cm/sec
I (near bottom)	0.92 cm/sec
II	2.09 cm/sec
III	3.46 cm/sec

Reference: City of New Bedford 301(h) application, page B-16.

level due to its momentum. Eventually, the momentum of the plume will be dissipated, and it will fall back in the water column to a level at which it is neutrally buoyant. The plume will then begin to spread out laterally. The region above the density equilibrium level or trapping level is identified as a waste field. Even though mixing is occurring from the point of discharge to the maximum height of rise, the dilution of the effluent with clean ocean water ceases when the plume reaches the bottom of the waste field or trapping level. The additional mixing which occurs in this field does not contribute to the plume's dilution in the sense that it does not lower the concentration of the effluent since it is mixing with previously discharged diluted effluent. Because of this phenomenon, it is more reasonable to look at the dilutions calculated for the density equilibrium level and ignore the additional dilution theoretically provided by the continued rise of the plume past this level. On this basis, the "worst case" initial dilution achieved from the New Bedford proposed diffuser is 60 to 1 for an effluent flow of 2.2 m^3/sec (50.0 MGD).

The initial dilutions for the five flows of interest are also computed using DKHPLM. Table 9 presents these dilutions and the associated heights of rise for the July 28, 1979, density profile.

Use of EPA Initial Dilution Models--

The applicant uses the EPA recommended model DKHPLM for the initial dilution computations.

TABLE 9. INITIAL DILUTIONS PREDICTED USING THE MODEL DKHPLM AND THE APPLICANTS WORST-CASE JULY DENSITY PROFILE

Flow m /sec (MGD)	Initial Dilution	Height of Rise m (ft)
Minimum - 0.483 (11.02)	112	3.2 (10.4)
Average - 1.097 (25.04)	74.4	4.0 (13.1)
Maximum - 2.018 (46.06)	58.8	4.7 (15.4)
Expected Maximum - 2.022 (46.15)	58.7	4.7 (15.4)
Ultimate Design - 3.162 (72.17)	50.1	5.2 (17.1)

Critical Initial Dilution with Respect to Ambient Dissolved Oxygen--

The applicant computes a single initial dilution and indicates that this value is critical in all respects. This is correct; however, as discussed previously, the critical initial dilution is that computed for the point at which the plume has reached its equilibrium level. Therefore, the critical initial dilution with respect to ambient DO is 58.7 to 1.

Critical Initial Dilution with Respect to Ambient pH--

The applicant computes a single initial dilution and indicates that this value is critical in all respects. This is correct; however, as discussed previously, the critical initial dilution is that computed for the point at which the plume has reached its equilibrium level. Therefore, the critical initial dilution with respect to pH is 58.7 to 1.

Critical Initial Dilution with Respect to Suspended Solids--

The applicant computes a single initial dilution and indicates that this value is critical in all respects. This is correct; however, as discussed previously, the critical initial dilution is that computed for the point at which the plume has reached its equilibrium level. Therefore, the critical initial dilution with respect to suspended solids is 58.7 to 1.

Effect of Ambient Currents and Stratification on the Plume--

The applicant's response to this subsection consists of an oceanographic report summarizing the results of drogue, current meter, and water quality measurements taken during the summer of 1979 and a supply of dilution water computation. The discussions on measurement techniques and data tabulations are not here reviewed. The review commentary concerns only that which is directly useful in the description of farfield dilution and water supply.

On the basis of the oceanography study of about 1-month duration in July and August, 1979, the applicant concludes:

1. The effluent plume travels to the northeast 3,000 m (9,842 ft) on a flooding tide and a similar distance to the southwest on an ebbing tide.

2. A net current to the north to northwesterly direction having speed 0.022 m/sec (0.043 knots) exists. The net current is not uniform in time or spatial location within the harbor and within Buzzards Bay.

3. The net flux pattern into and out of Buzzards Bay is not completely understood.

Although not explicitly stated by the applicant, the first conclusion is valid only at the site of the proposed outfall. Figures 9 and 10, respectively, show drogue paths on a flooding tide (July 31, 1979) and on an ebbing tide (August 21, 1979). The movement near the present site is northward on a flooding tide and southward on an ebbing tide. The tidal excursion of the present site is roughly one-half the tidal excursion at the proposed site. Table 10 summarizes some of the statistical information derived from current meter measurements, the locations of which are shown on Figure 3. Station A' is near the present outfall, while Station C' is near the proposed outfall site. At the proposed site the average current is to the northwest at a depth of 4.7 m (15.4 ft) and to the north at 9.3 m (30.5 ft) depth. The effluent plume is trapped 6.9 m (22.6 ft) below the water surface. Hence, the appropriate net current direction and speed is approximately the average of those computed at station C' at the two depths. The net current direction for Station A' is northerly as well. The applicant's Conclusion 2 is valid although the net speed given is somewhat low; Conclusion 3 is also valid.

The applicant uses these first two conclusions to argue that there is a sufficient supply of dilution water. The conceptualization of the argument is illustrated in Figure 11. The flooding and ebbing tide directions are first shown. Then the flux available for dilution is compiled using the reasoning that since the net current is perpendicular to the tidal excursion, the cross-sectional area is two times the tidal excursion times the height of rise. This computation is not appropriate for the intended purpose. The initial difficulty is that the effluent plume is over the

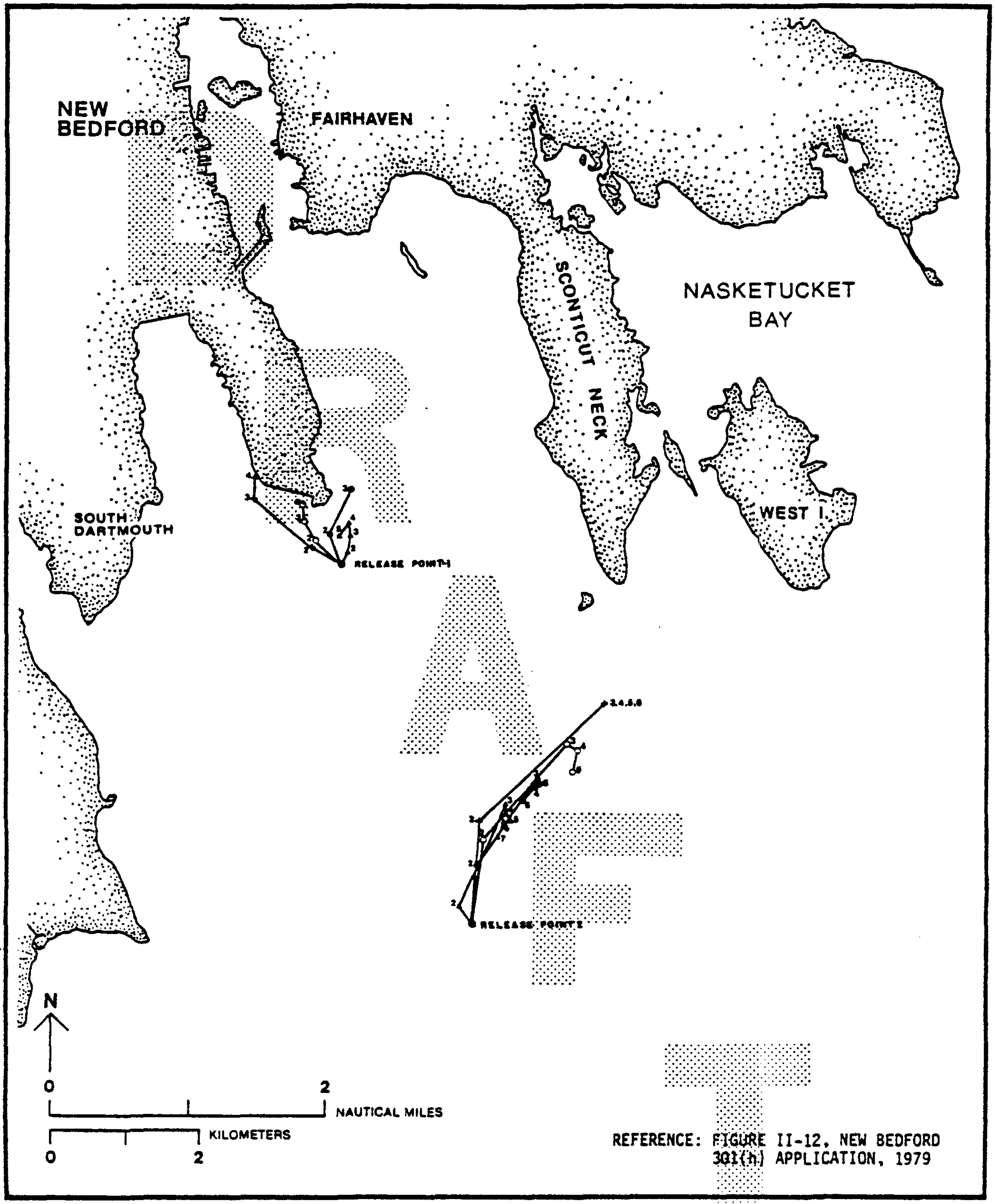


Figure 9. Drogue movements on a flooding tide, July 31, 1979 (New Bedford, MA).

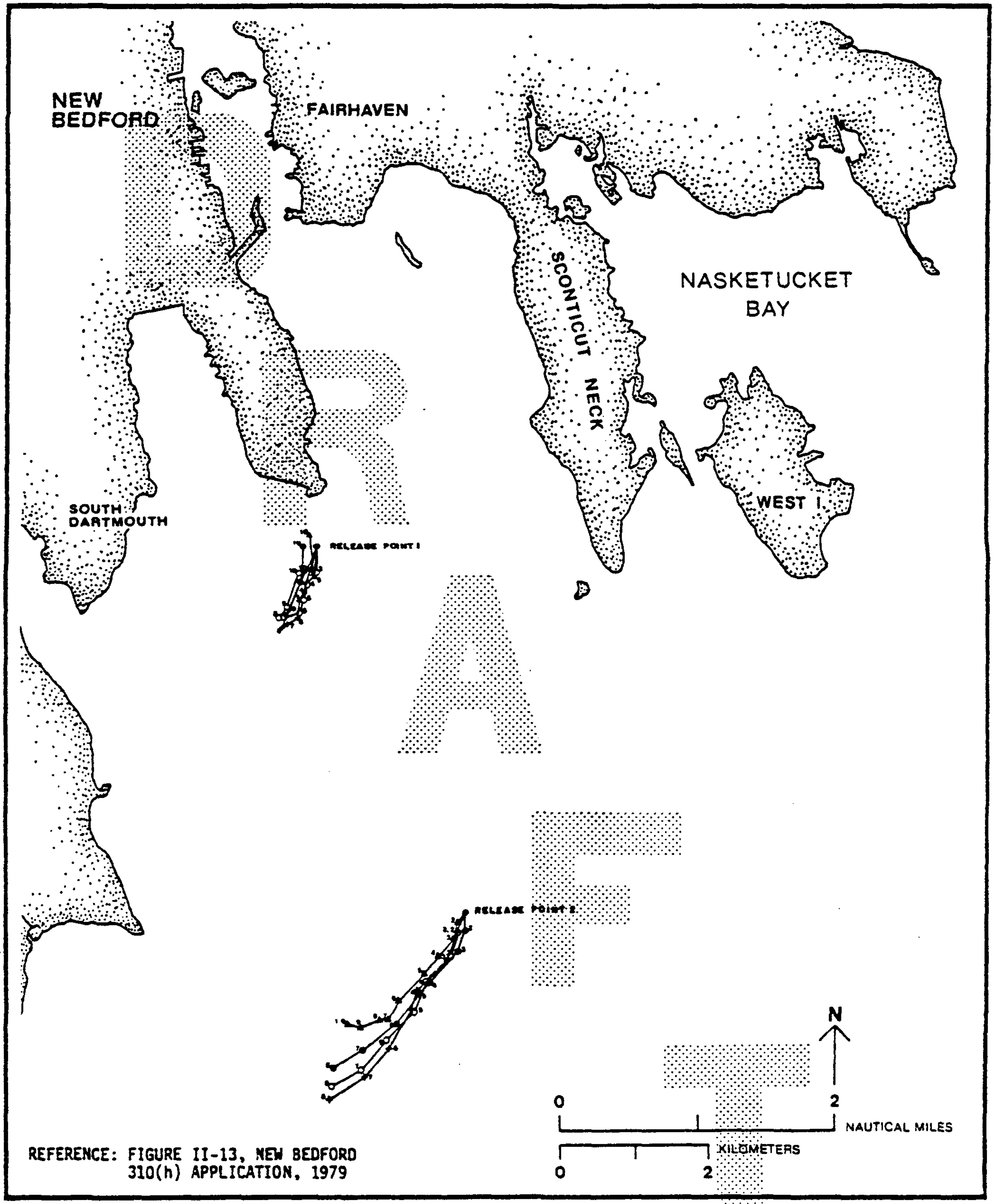
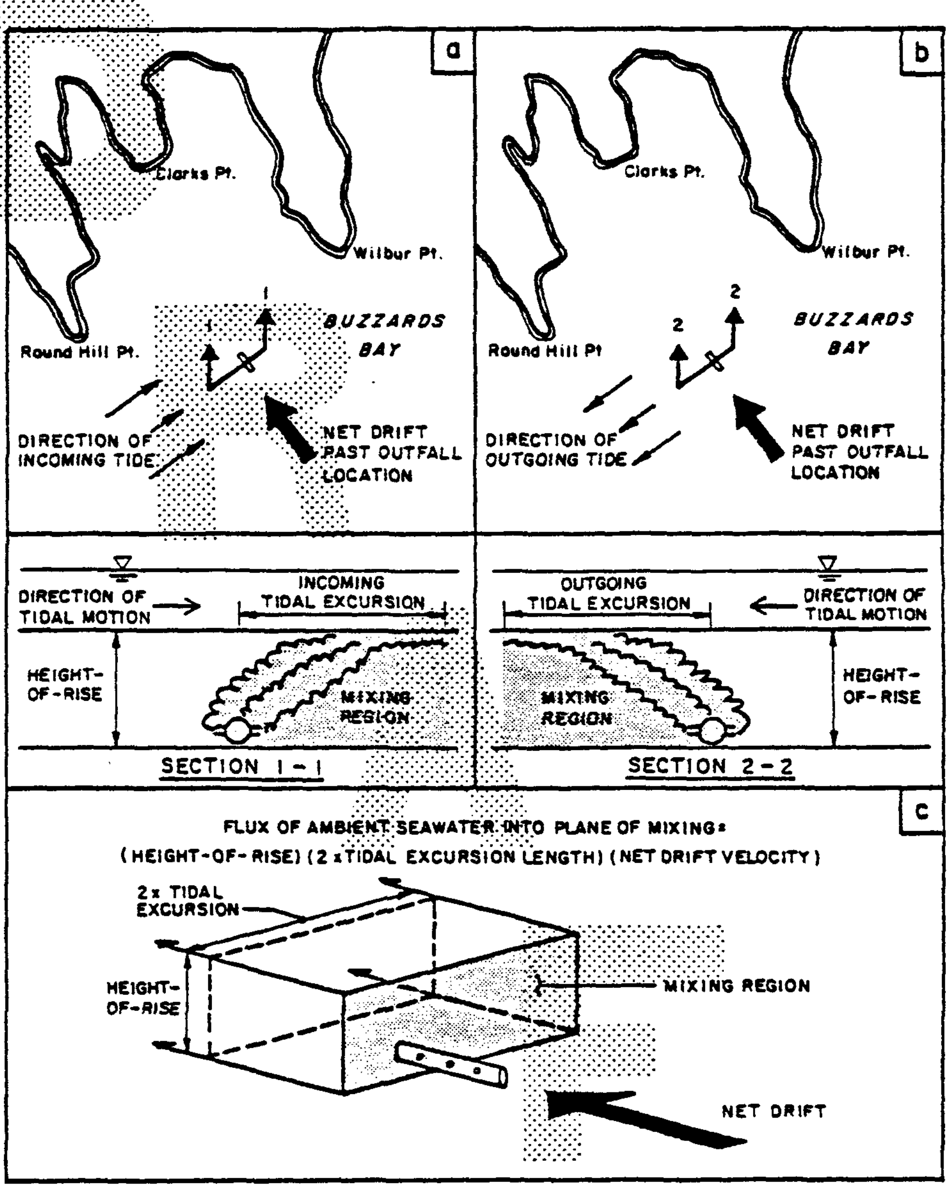


Figure 10. Drogue movements on an ebbing tide, August 21, 1979 (New Bedford, MA).

TABLE 10. STATISTICAL SUMMARY OF APPLICANT'S CURRENT METER DATA, NEW BEDFORD, MA

	Current Speed (cm/sec) East	North	Speed
Station A'			
Mean	-1.13	4.15	6.49
Standard deviation	3.55	4.76	3.42
Station C' (4.7 m depth)			
Mean	-2.90	3.45	14.17
Standard deviation	12.82	8.75	7.77
Station C' (9.3 m depth)			
Mean	0.11	2.83	12.11
Standard deviation	10.46	8.90	7.07



REFERENCE: FIGURE B-5, NEW BEDFORD 301(h) APPLICATION, 1979

Figure 11. Applicant's conceptualization of plume movement due to tidal action at the proposed diffuser site, New Bedford, MA.

diffuser only a short time. For this time only is a current available for initial dilution, and the current used should be the net current at a particular time. If this type of argument were to be used, then the supply of dilution water at a given time is given by

$$uhL$$

where:

u = net current speed

h = height of rise of the effluent plume

L = projected length of the diffuser relative to the current velocity vector.

On the average

u = 14 cm/sec (0.27 knots)

h = 6.9 m (22.6 ft)

L = 250 m (820 ft).

In this case

$$uhL = 241.5 \text{ m}^3\text{/sec (5,512 MGD) while,}$$

$$SaQ = 121.3 \text{ m}^3\text{/sec (2,769 MGD)}$$

since

$Q = 2.022\ m^3/sec$ (46.15 MGD)

$Sa = 60.$

By this line of reasoning, on the average a sufficient supply of water exists. The supply does not exist for the 10 percentile current speed, however, which the applicant claims is 3 cm/sec (0.06 knots).

In the absence of any constraining physical boundaries, the plume creates its own current field sufficient to achieve the stated dilutions. A somewhat technical argument follows which demonstrates that, on the basis of laboratory experiments, SaQ is greater than or less than uhL naturally for various u's and hence SaQ computations are not indicative of whether or not a sufficient supply of dilution water exists.

Roberts (1977) contains a description of laboratory experiments which were employed to determine the dilution achieved by a line source in an unstratified fluid. The results show that the behavior of the effluent after leaving the diffuser pipe is strongly dependent on the value of F,

where:

$$F = \frac{u^3}{b}$$

u = ambient current speed

$b = g'q$

$$g' = g\left(\frac{\Delta\rho}{\rho}\right)$$

ρ = density of seawater at the diffuser depth - density of effluent

$\Delta\rho$ = density of effluent

g = acceleration due to gravity

q = effluent flow per unit length of diffuser.

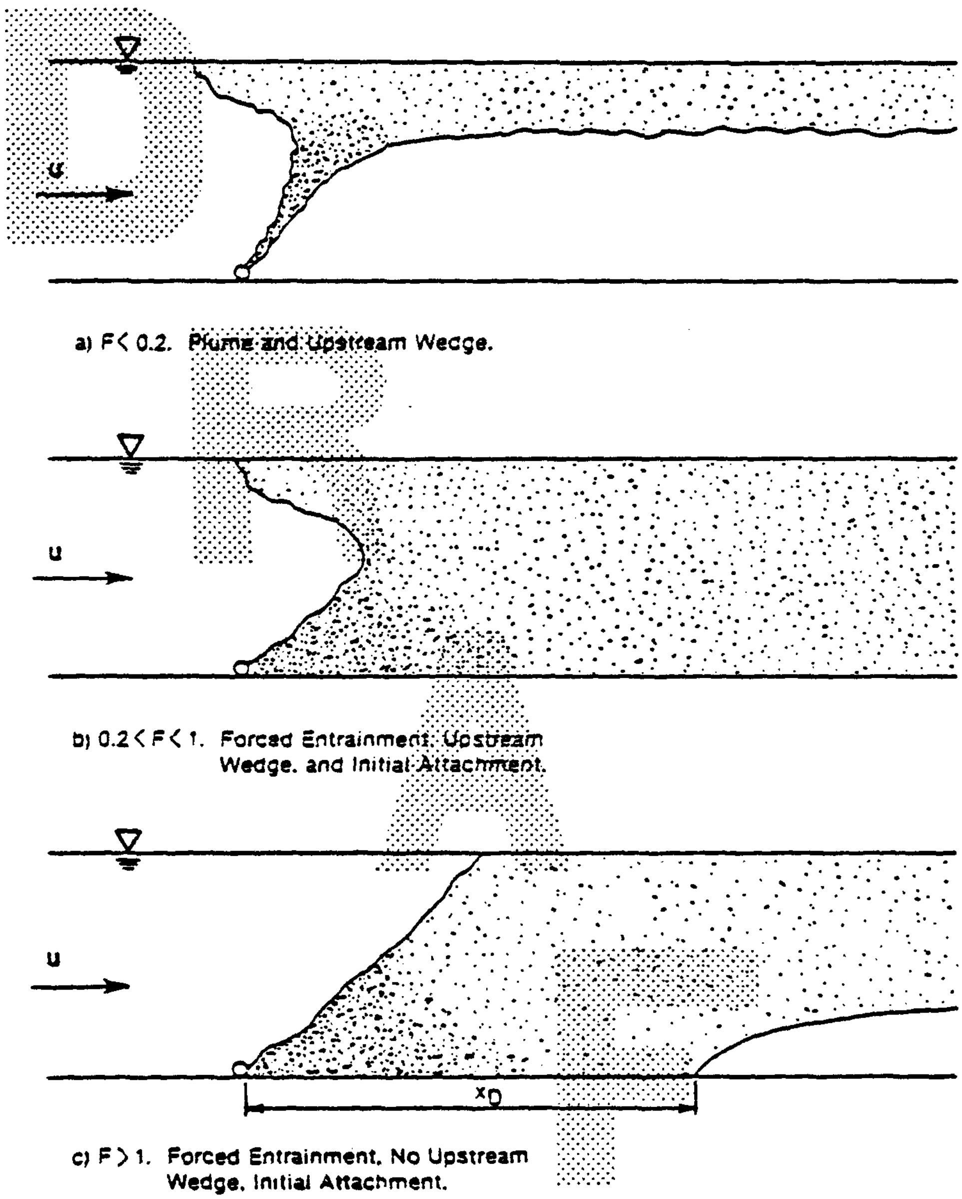
Physically, F is the ratio of the energy flux of stagnation pressure to (i.e., divided by) the energy of buoyancy. Figure 12 from Roberts (1977) shows the three flow regimes for various ranges of F when the direction of the ambient current is perpendicular to the diffuser axis. The actual dilutions achieved for ambient currents having three directions relative to the diffuser axis as functions of F are shown in Figure 13 (from Roberts 1977). On this figure, S_m is the minimum surface dilution. The relevant dilution for water quality computations is the average dilution S_a. Approximately $S_a = S_m/0.7$. Note that for small F,

$$\frac{S_a q}{uH} = \frac{0.27F^{-1/3}}{0.7}$$

while for large F

$$\frac{S_a q}{uH} = \frac{0.58}{0.7} = 0.83 \text{ (perpendicular flow)}$$

where:



REFERENCE: ROBERTS, 1977

Figure 12. Flow regimes for a plume of infinite length in a perpendicular current, New Bedford, MA.

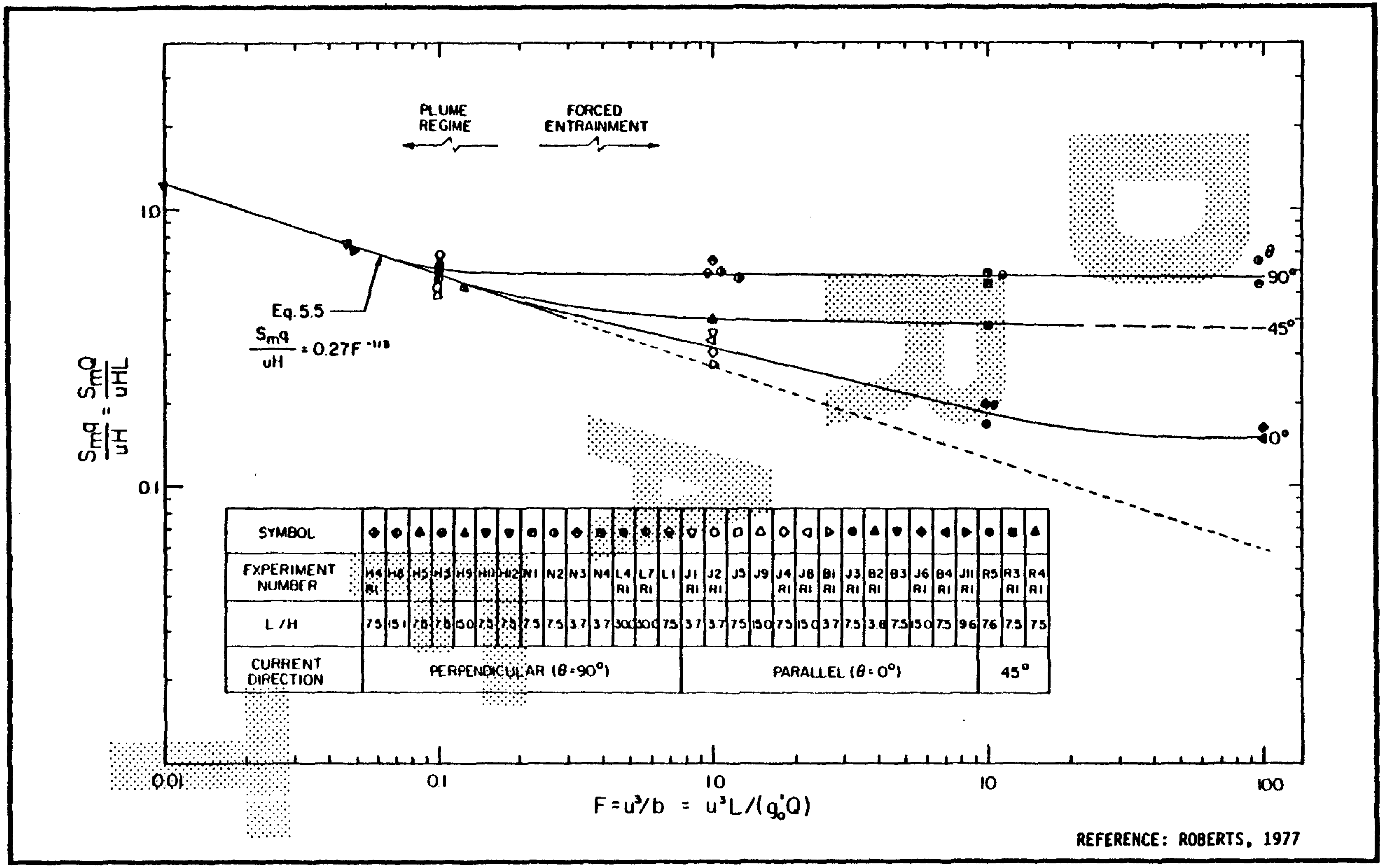


Figure 13. Experimental measurements of minimum surface dilution for a finite line source of buoyancy flux in a current, New Bedford, MA.

q = effluent flow per unit diffuser length

u = current speed

H = water depth (= height of rise for an unstratified fluid).

Using the definition of F, the equation for S_a for small F can be written

$$S_a = 0.38(g')^{1/3} q^{-2/3} H$$

and hence, is independent of u.

Roberts (1979) contains a method for computing the trapping level and dilution for a stratified fluid using the unstratified fluid results, a variant of which is employed for the July 28, 1979, density profile which gives the lowest critical initial dilution. Table 11 contains values for Roberts F for various ambient current speeds and the maximum expected flow rate. The effect of current speeds in the range 0 - 0.4 m/sec (0 - 1.3 ft/sec) is examined. Initial dilutions computed using Roberts' method and the July 28, 1979, critical profile are also shown in Table 11. These results indicate that for low current speeds the initial dilutions predicted with Roberts' method are somewhat less than the dilution predicted with the DKHPLM model.

TABLE 11. ROBERTS F AND INITIAL DILUTIONS FOR CRITICAL DENSITY PROFILE FOR NEW BEDFORD, MA, APPLICATION

Robert's F for Various Current Speeds

Current Speed m/sec	Current Speed ft/sec	Robert's F for Flow Rate 2.022 m^3/sec (46.14 MGD)
0.01	0.03	0.0006
0.03	0.10	0.015
0.05	0.16	0.070
0.10	0.33	0.56
0.15	0.49	1.9
0.20	0.66	4.5
0.25	0.82	8.7
0.30	0.98	15
0.35	1.15	24
0.40	1.31	36

Initial Dilutions Predicted with Robert's Method

Current Speed m/sec	Current Speed ft/sec	Dilution for Flow Rate 2.022 m^3/sec (46.14 MGD)
0.01	0.03	38
0.03	0.10	38
0.05	0.16	38
0.10	0.33	51
0.15	0.49	63
0.20	0.66	72
0.25	0.82	81
0.30	0.98	88
0.35	1.15	96
0.40	1.31	102

The supply of dilution water is intrinsically included in the results of Roberts as shown previously in Figure 10. For small F,

$$\frac{S_a Q}{ubH} = 0.38F^{-1/3}$$

For F = 0.05, $0.38F^{-1/3} = 1$, and as F becomes smaller, $0.38F^{-1/3}$ increases. In this latter case,

$$\frac{S_a Q}{ubH} > 1$$

which indicates that the rising plume induces its own circulation field which supplies water sufficient to achieve the stated dilution. As F (and hence u, for a fixed effluent flow Q) increases, the ambient current flow field becomes more important than the induced field. For ambient currents flowing perpendicularly to the axis of the diffuser, this begins to become noticeable for F approximately equal 0.08. When F reaches 0.15, the ambient current field completely dominates the induced flow field, and

$$\frac{S_a Q}{ubH} = \text{constant} = 0.83 < 1$$

Roberts (1977) is based directly on laboratory measurements. The EPA computer program DKHPLM is based on physical principles and calibrated to model experiments. DKHPLM likewise induces a current field of sufficient strength to achieve the computed dilutions. The DKHPLM model employs entrainment functions which are functions of the local Froude number, velocities, plume diameter, and spacing. Thus, a priori, there is little reason to require that

$$S_a Q = ubh,$$

where:

u = 10 percentile ambient current.

As shown previously, the 10 percentile current speed for New Bedford is such that F is much less than 0.055 (see Table 8) and is in the range where induced currents dominate ambient currents (according to Roberts). The discrepancies between Roberts and DKHPLM dilutions may be due to the differences between the physically and mathematically induced current fields or other causes. Fischer et al. (1979), for example, cautions that Roberts' "experiments were performed at a small scale where the Reynolds numbers are quite small. Their applicability to the field is, therefore, still an unanswered question."

In this review, the DKHPLM results are accepted as fact.

Zone of Initial Dilution Boundary--

The applicant states that the zone of initial dilution for the proposed diffuser is a rectangle centered about the diffuser. The dimensions of the rectangle are stated to be approximately 16.1 m (52.8 ft) by 264.3 m (867.1 ft). These dimensions are computed with the maximum height of rise of the plume predicted with the DKHPLM model for the "worst case" conditions discussed previously.

If the formula based on the assumed full water depth of 13.7 m (45 ft) is used to calculate the zone of initial dilution dimensions, the width is 29.2 m (95.8 ft) and length is 277.4 m (910.1 ft).

Zone of Initial Dilution Coordinates--

The applicant reports the coordinates at the corners of the zone of initial dilution as follows:

41^{o} 32' 12" N	70^{o} 52' 03" W
42^{o} 32' 03" N	70^{o} 51' 57" W
41^{o} 32' 00" N	70^{o} 52' 00" W
41^{o} 32' 10" N	70^{o} 52' 07" W

It appears that a typographical error was made in the second set of coordinates shown above. For the latitude listed as 42^{o} 32' 03" N it is assumed that 41^{o} 32' 03" N was intended.

The coordinates that the applicant reports for the corners of the ZID define an inappropriately large area. As part of this review, the latitude and longitude of each corner are converted to Lambert state plane coordinates using the methods of Claire (1973). The distances between the corners of the ZID are then computed using the Lambert state plane coordinates. The lengths of the sides are 310 m (1,017 ft), 116 m (381 ft), 349 m (1,145 ft), and 111 m (364 ft). Using an average of the length and width distances shown to compute the area, a ZID approximately 9 times larger than the area encompassed by a rectangle of the dimensions reported in the previous section based on maximum height of rise is obtained. Therefore, these coordinates do not appear to be correct. Since the exact location of the diffuser awaits precise location of the proposed outfall itself (based on refined offshore topography information), revised ZID coordinates are not calculated herein.

Ocean Discharge--

The applicant presents historical temperature, salinity, and density profiles which are representative of seasonal conditions. However, these historical data are not gathered specifically at the existing or proposed outfall sites. The historical data are discussed in the Ambient Density Stratification subsection of this review. The applicant's site-specific data collection effort was focused on summer conditions. In Appendix III of the application the applicant describes the oceanographic data collection effort as follows.

"A great deal of site specific oceanographic data were collected by the applicant in studying alternative to secondary treatment for a discharge to the New Bedford harbor area. An oceanographic survey was conducted by Clearwater Consultants during the summer of 1979. The results of this work are presented here as Appendix IV.

Also during the summer of 1979, personnel from Camp Dresser and McKee Inc. (CDM) collected data at the locations identified in Figure A-2. In response to Question 1-3, certain of these density-related data were presented--other information relevant *to DO is presented in Section 2. However, the applicant has* chosen not to report all data in detail. For the period of August 15-17 (the sampling period) all data remain on file at CDM and can be made available if required. Measurements which were made include temperature, salinity, conductivity, total coliform bacteria, pH, DO, and SS versus depth as well as Secchi disk readings."

Figure 3 (applicant's Figure A-2) shows the water sampling locations. Table 12 indicates the oceanographic data which were available for review. As indicated, data pertaining to suspended solids, Secchi disc readings, and total coliform bacteria are not provided.

TABLE 12. OCEANOGRAPHIC DATA PRESENTED IN THE NEW BEDFORD, MA, APPLICATION

Station	Date	Temperature	Salinity	Dissolved Oxygen	pH
A'	July 28, 1979	X	X		
B'	July 28, 1979	X	X		
C'	July 28, 1979	X	X		
14	July 21, 1979	X	X	X	X
15	July 31, 1979	X	X	X	X
17	July 31, 1979	X	X	X	X
PL1	July 31, 1979	X	X	X	X
PL2	July 31, 1979	X	X	X	X
PL3	July 31, 1979	X	X	X	X
PL4	July 31, 1979	X	X	X	X
PL5	July 31, 1979	X	X	X	X

During the summer of 1979, circulation in Buzzards Bay was investigated with current meter and drogue studies. The applicant states that current meter measurements were made at six sites (see Figure 3). However, only the current data measured by Camp, Dresser and McKee, Inc. (Stations A', B', and C') are presented in the application. Thermographs were also installed with the current meter mooring at Station A', B', and C'. Time series for currents and temperatures which are available are summarized below.

- Station A': Currents and temperatures at 6 m (20 ft) for July 28 - August 29, 1979.

- Station B': Currents and temperatures for July 28 - August 13, 1979.

- Station C': Currents and temperatures for July 28 - August 18, 1979.

The applicant states that data were not available at Stations B' and C' for the latter half of the sampling period due to a fouled tether and vandalism.

Drogue studies were conducted on July 31, 1979, and August 21, 1979. Drogues were released in the vicinity of the existing outfall and at a position approximately 1,000 m (3,281 ft) east of Great Ledge (near the proposed outfall site). Two types of drogues were employed: a surface marker and a subsurface drogue. One surface marker [at a depth of 0.5 m (1.6 ft)] and drogues set at depths of 1.8 m (5.9 ft), 4.3 m (14.1 ft), and

7.3 m (24.0 ft) were released at each of the two sites. Drogues were tracked from approximately 0712 EDT to 1559 EDT on July 31, 1979. The experiment was terminated due to the weather. On August 21, 1979, drogues were tracked from approximately 0815 EDT until 1439 EDT, at which time the Coast Guard inadvertantly retrived several of the drogues.

No detailed discussion is presented in this section on the fate of the material in the farfield and the plume dynamics which could be expected as a result of the current measurements which were obtained. The applicant states, "The effluent plume is carried roughly northeast on the flood and southwest on the ebb. Net flux patterns into and out of Buzzards Bay are complex and not completely understood, except that on each tidal cycle there is exchange with Vinyard Sound, Rhode Island Sound, and Cape Cod Bay, which guarantees dispersion of constituents from Buzzards Bay."

The regulations require an assessment of the environmental effects of direct freshwater runoff from coastal areas. The applicant contends that the

> "pollution load impact of their improved discharge would not appear to be any more detrimental if pollution loads from extraneous sources (direct runoff) were removed. This contention is based on the analyses presented in Sections 2 through 4 where--outside the ZID--water quality criteria are shown to comply with State standards even when ambient conditions are assumed to be 'worst-case'. Even if ambient

conditions were to improve because of structural or non-structural controls applied to direct runoff from the coast, the water quality impacts of the modified discharge would be lessened rather than worsened. The applicant, however, is willing to document estuary mass emission rates if required by EPA."

Section 2. Compliance with BOD or DO

Effluent BOD--

The effluent from the New Bedford wastewater treatment plant exceeds the criteria in 40 CFR 133.102(a) which specify that the 30-day average BOD_5 concentration must be 30 mg/l or less and the 7-day average BOD_5 concentrations must be 45 mg/l or less. The applicant estimates the 1986 effluent BOD_5 concentration will be 97 mg/l based on the applicant's average influent concentration of 138 mg/l and the design removal efficiency of 30 percent shown in Appendix XX of the application. At present the treatment plant removal efficiency is low. The monthly average effluent BOD_5 concentration during the period January, 1978, through February, 1981, has been between 65 and 321 mg/l (Table 13). The applicant expects that control of the combined sewer discharges to the treatment plant and improvement in the plant processes will improve plant efficiency.

State Standards--

The waters of New Bedford Harbor are designated Class SA by the Commonwealth of Massachusetts. The dissolved oxygen concentrations must not drop below a minimum of 6 mg/l. There is no receiving water standard for BOD.

TABLE 13. BOD_5 DATA FOR PRESENT NEW BEDFORD TREATMENT PLANT[a]

Year	Month	Influent BOD_5, mg/l Minimum	Influent BOD_5, mg/l Average	Influent BOD_5, mg/l Maximum	Effluent BOD_5, mg/l Minimum	Effluent BOD_5, mg/l Average	Effluent BOD_5, mg/l Maximum
1978	January	25	98	242	15	65	117
	February	13	114	310	6	73	145
	March	45	125	286	6	101	178
	April	34	143	222	27	135	222
	May	54	131	219	45	129	262
	June	52	157	241	49	137	229
	July	58	148	282	54	140	235
	August	-	-	-	-	-	-
	September	-	-	-	-	-	-
	October	147	-[b]	355	65	-	213
	November	117	342	417	130	321	424
	December	73	151	310	46	160	324
1979	January	12	91	195	7	78	202
	February	53	84	229	31	87	210
	March	37	93	183	3	100	186
	April	22	93	159	28	108	162
	May	30	-	146	18	-	135
	June	35	99	188	26	123	218
	July	41	99	173	69	129	218
	August	30	105	222	28	111	299
	September	34	121	207	39	98	340
	October	48	105	176	6	110	207
1980	January	45	115	291	30	94	184
	February	34	99	177	6	76	159
	June	30	113	216	32	94	166
	July	26	162	237	12	156	297
	August	132	191	279	114	177	267
	September	62	180	348	80	181	260
	October	123	262	435	100	230	424
	November	105	213	351	94	198	286
	December	90	236	483	66	160	330
1981	January	61	168	343	46	146	342
	February	64	147	249	70	132	212

[a] Data are from Discharge Monitoring Reports for New Bedford treatment plant.

[b] Only seven measurements reported.

Effluent Dissolved Oxygen--

The applicant sampled the dissolved oxygen of the effluent at the junction box of the clarifier overflow. The dissolved oxygen concentration was 6.5 mg/l. The date and flow rate at the time of sampling are not given. The data in the discharge monitoring reports (Table 14) show that the dissolved oxygen has been measured at 0.0 mg/l several times during this period of record, which is used as a worst-case estimate in this review.

Travel Times--

The applicant computes the total travel time through both the existing and proposed outfalls as shown in Table 15. The travel times to the existing outfall are based on a length of 1,006 m (3,300 ft) and a diameter of 1.52 m (60 in). The times calculated in this review are within 1 min of the applicant's calculations for the existing outfall site.

The applicant's calculations for the proposed site could not be duplicated. Estimates are made in this review using the following equation:

$$T = \frac{(L_1 + L_2)A}{60 \times Q}$$

where:

T = travel time, min

TABLE 14. EFFLUENT DISSOLVED OXYGEN DATA[a]

Month	Dissolved Oxygen, mg/l 1978	1979	1980	1981
January	8.0	8.3	7.3	8.8
February	5.3	8.5	8.6	5.6
March	6.4	8.6	-	-
April	4.5	0	-	-
May	5.3	5.3	-	-
June	0.4	2.6	3.5	-
July	1.2	0.2	0.5	-
August	-	3.2	0.7	-
September	-	1.0	2.6	-
October	0.9	1.0	4.0	-
November	0	0	3.8	-
December	1.0	-	7.0	-

[a] Data are from Discharge Monitoring Reports for New Bedford treatment plant.

Note: Dash indicates data are not available.

TABLE 15. ESTIMATED TRAVEL TIMES THROUGH EXISTING AND PROPOSED OUTFALLS

Flow Condition	Flow Rate m^3/sec	Flow Rate MGD	Travel Time Through Existing Outfall, min Applicant[a]	Travel Time Through Existing Outfall, min Review	Travel Time Through Proposed Outfall and Diffuser, min Applicant[a]	Travel Time Through Proposed Outfall and Diffuser, min Review
Minimum hourly	0.483	11.0	64	63	501	636
Average hourly	1.097	25.0	28	28	220	280
Maximum hourly	2.018	46.06	15	15	120	152
Expected maximum hourly in 1988	2.022	46.15	15	15	119	152

[a] Applicant's times are from Table B-7 of the application.

L_1 = length of existing stormwater outfall = 305 m (1,000 ft)

L_2 = length of proposed extension including diffuser = 6,707 m (22,000 ft)

A = cross-sectional area of outfalls = 2.63 m^2 (28.3 ft^2).

The travel times computed in this manner are longer than the applicant's times by up to 125 min (Table 15). The total length apparently used by the applicant is 5,520 m (18,110 ft). No reference to this or a similar length was found in the application. The IDOD values measured by the applicant did increase at longer travel times, so the IDOD at minimum flow conditions could be higher than the applicant's value of 1.13 mg/l.

Immediate Dissolved Oxygen Demand--

The applicant measured IDOD values on three samples for each of the flow conditions shown in Table 15. The average of the three replicates is used as the IDOD value. The results are as follows:

Flow Condition	Average IDOD, mg/l
Minimum hourly	1.13
Average hourly	0.3
Maximum hourly	0.1
Exp. max. hourly	0.1

The laboratory data sheets show that the laboratory procedure and calculations are correct, although the experimental conditions are different from those expected to occur. The effluent dissolved oxygen levels of the samples were between 6.5 and 6.9 which is higher than during the spring and summer as shown by the data in Table 14. The receiving water dissolved oxygen concentration of 7.8 mg/l is close to the observed minimum summer concentrations at the proposed outfall site of 7.1 mg/l. A dilution ratio of 1:1 was used for the tests. The lowest dilution ratio at the proposed outfall site is 59:1. Theoretically, if the IDOD is fully satisfied at the low dilution, the fraction of effluent used in the test should not affect the results. However, laboratory tests have shown that in some instances the results do change.

Background Dissolved Oxygen Data--

Dissolved oxygen data are available from 20 stations shown in Figure 14 near the existing and proposed outfall sites on August 16 and 17, 1979. At the sites near the outfalls the data (Table 15) show that concentrations below 6 mg/l occur near the existing outfall site and close to shore. Other data are available for the period November, 1975, through April, 1976, in New Bedford Harbor (Ellis et al., 1977). These data reveal that higher dissolved oxygen concentrations existed than in August, 1979, so the data are not used in this review.

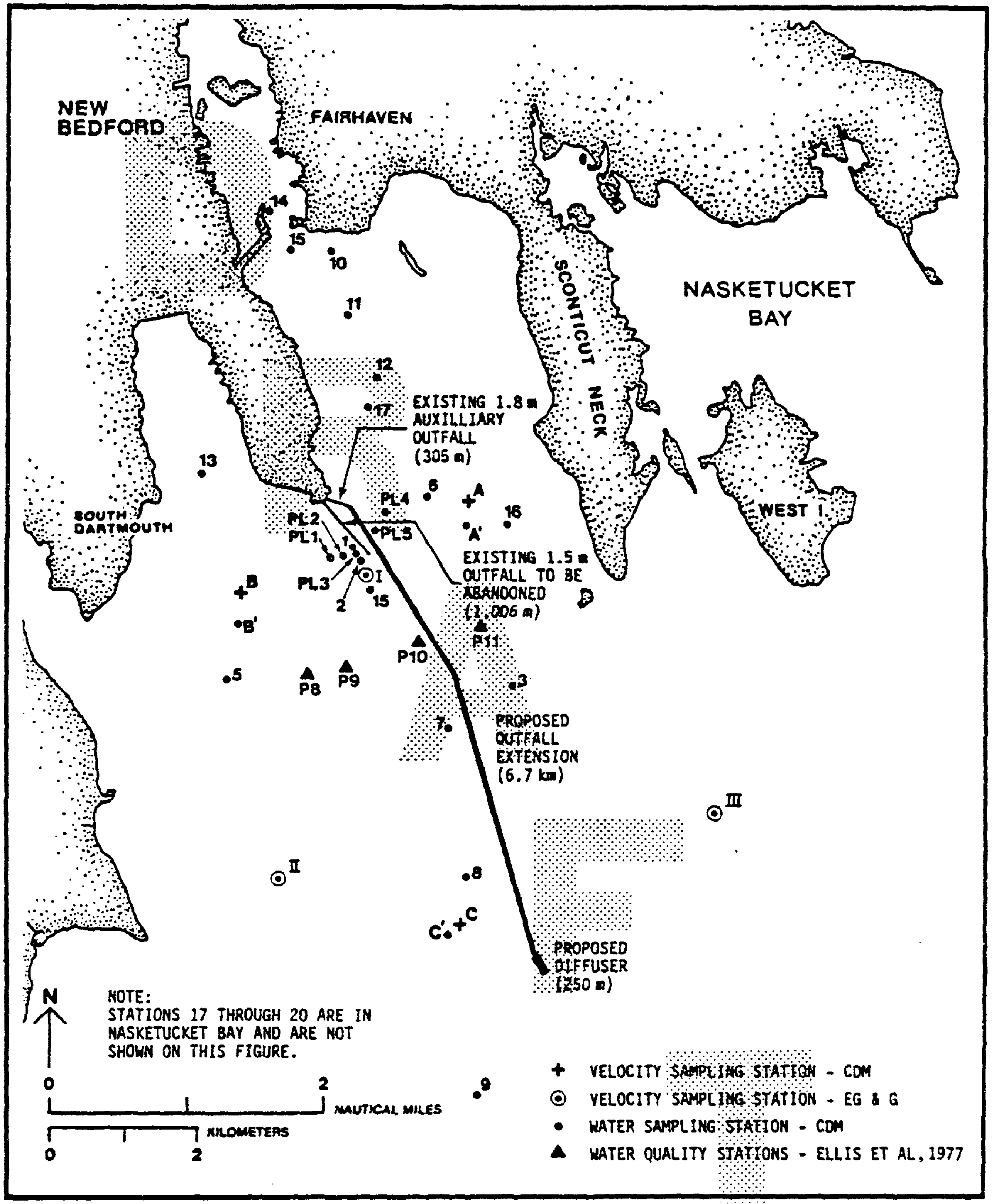


Figure 14. Location of water quality sampling stations, New Bedford, MA.

TABLE 16. DISSOLVED OXYGEN DATA FOR AUGUST, 1979[a]

Depth m	Depth ft	Dissolved Oxygen, mg/l Station 1	2	3	4	8	9	11	12
0	0	7.0	7.3	7.0	7.3	7.5	7.8	6.8	7.1
1.5	5	7.1	7.6	7.1	7.4	7.8	8.1	6.8	7.2
3.0	10	7.2	7.3	7.5	7.7	7.9	8.1	7.2	6.9
4.6	15	7.3	7.4	7.6	7.8	8.0	8.1	6.0	6.6
6.1	15	7.3	7.4	7.6	7.7	8.0	8.1	5.4	6.3
7.6	25	6.3	6.2	7.5	7.6	8.0	8.0		5.7
9.1	30	5.7		7.3	7.2	7.7	7.9		
10.7	35			6.8	6.7	7.7	7.5		
12.2	40			6.7		7.7	7.1		
13.7	45					7.2	7.1		
15.2	50						7.1		

[a] Data are from letter from city of New Bedford, Massachusetts, to the U.S. Environmental Protection Agency dated May 20, 1981.

The lowest ambient dissolved oxygen at the proposed outfall site (Station 9) averaged over the height of rise of the plume is 7.2 mg/l. This concentration is used in this review as the ambient dissolved oxygen concentration. The applicant presents the dissolved oxygen profiles at Stations 8 and 9, then states that 6.5 mg/l represents a worst-case estimate of ambient conditions since all values near the proposed outfall are 7.0 mg/l or above. The dissolved oxygen concentration of 6.5 mg/l is used by the applicant in subsequent calculations.

The final dissolved oxygen concentration is computed using the following equation:

$$DO_f = DO_a + (DO_e - IDOD - DO_a)/Sa$$

where:

DO_f = final dissolved oxygen concentration, mg/l

DO_a = ambient dissolved oxygen concentrations, mg/l

DO_e = dissolved oxygen of effluent, mg/l

IDOD = immediate dissolved oxygen demand, mg/l

Sa = initial dilution.

The applicant's calculation shows no change in the final dissolved oxygen concentration based on the following equation:

$$DO_f = 6.5 + (6.5 - 1.13 - 6.5)/76 = 6.48 \text{ mg/l}.$$

For the more critical case when the dissolved oxygen of the effluent is 0.0 mg/l and the initial dilution is 59 (from the review dilution calculated for the expected maximum flow in Part B, Section 1), the final dissolved oxygen concentration decreases to 6.4 mg/l. If the averaged ambient dissolved oxygen concentration of 7.2 mg/l is substituted for 6.5 mg/l, the final concentration is 7.1 mg/l.

Compliance with Dissolved Oxygen Criteria--

The calculations show that the final dissolved oxygen concentrations would be above the state minimum of 6 mg/l at the proposed outfall site. Data were not available to calculate final dissolved oxygen concentrations at the existing site. However, available field data show that dissolved oxygen concentrations below 6 mg/l have occurred in the vicinity of the existing outfall site.

Effluent BOD--

The applicant presents effluent BOD_5 concentrations at the required flow rates as follows:

- 180 mg/l, minimum hourly flow
- 136.5 mg/l, average hourly flow
- 159 mg/l, maximum hourly flow
- 196.5 mg/l, expected maximum hourly flow.

The source of these concentrations is not discussed. The effluent BOD_5 concentrations exhibited a range from 3 mg/l to 421 mg/l for the period January, 1978, through February, 1981 (Table 13). Hourly flow rates and BOD_5 concentrations were not available to compare to the applicant's concentrations. As a worst case, the maximum monthly average effluent BOD_5 concentration of 321 mg/l is used along with the applicant's values to compute final BOD_5 concentrations. The removal efficiency of the treatment plant is projected to increase to 30 percent. The estimated average effluent BOD_5 concentration is 97 mg/l in 1986 (Appendix XX of the application). The maximum monthly average influent BOD_5 concentration based on available data in Table 13 is 342 mg/l. Using the design 30-percent removal efficiency, the estimated maximum effluent BOD_5 concentration is 239 mg/l.

Final BOD Following Initial Dilution--

The applicant does not estimate final BOD_5 concentrations. Estimates are made in this review for use in subsequent questions. No ambient BOD_5

concentrations were available so the results presented here should be interpreted as increases above ambient. Using the applicant's effluent BOD_5 concentrations, the increases in BOD_5 concentration above ambient are between 1.6 and 3.3 mg/l (Table 17). For the worst-case analysis, the increase above ambient is estimated as 5.4 mg/l under present treatment plant performance conditions. After the improvements to the treatment plant are operational, the increases in final BOD_5 concentrations would be 1.3 mg/l under average conditions and 4.0 mg/l under maximum conditions.

Compliance with State BOD Criteria--

The state of Massachusetts does not have receiving water standards for BOD. The state does have a minimum standard for dissolved oxygen of 6 mg/l.

BOD Exerted after Initial Dilution and Dissolved Oxygen Demand of Sediments--

In Table IX-3 of Appendix IX the applicant predicts dissolved oxygen depletions due to resuspension of sediments and due to a steady demand of undisturbed sediment. The applicant does not address the question of dissolved oxygen depletion due to BOD exertion in the water column. In this review, however, BOD exertion within the water column is also analyzed.

Farfield dissolved oxygen depletion is computed using an extension of an approach developed by Brooks (1960). This approach assumes that as the waste field spreads laterally, it entrains dilution water while BOD is

TABLE 17. FINAL BOD_5 CONCENTRATIONS

Flow Condition	Initial Dilution[a]	Effluent BOD_5 (mg/l)	Final BOD_5[b] (mg/l)
Existing Treatment Plant Performance			
Minimum hourly	112	180	1.6
Average hourly	74	136.5	1.8
Maximum hourly	59	159	2.7
Expected maximum hourly	59	196.5	3.3
Worst case maximum	59	321	5.4
Projected Treatment Plant Performance			
Average	74	97	1.3
Maximum	59	239	4.0

[a] These are the review dilutions from Part B, Section 1 of this document.

[b] Ambient BOD_5 concentration is assumed to be 0.0 mg/l in all cases.

simultaneously being exerted. Vertical spreading is neglected. The lateral turbulent diffusion coefficient is assumed to be constant and is calculated based on the length of the proposed diffuser and the four-thirds law (Brooks 1960).

Based on the final BOD_5 concentrations shown previously in Table 17, the following "worst case" dissolved oxygen depletions are predicted:

Final BOD_5, mg/l	Condition	Dissolved Oxygen Concentration Following BOD Utilization
1.3	Average flow, 30-percent removal	6.3
4.0	Maximum flow, 30-percent removal	6.0
5.4	Maximum flow, present removal efficiency	5.8

The receiving water data used to make these predictions are:

- Ambient dissolved oxygen level = 6.5 mg/l (applicant's worst-case estimate)
- Water temperature = 22°C
- BOD decay rate = 0.25/day.

In the case where the final BOD_5 is 5.4 mg/l, the dissolved oxygen level can drop below the standard of 6.0 mg/l when the critical ambient conditions shown above exist. Once the efficiency of the treatment plant is improved to at least 30 percent, the dissolved oxygen level should not drop below 6.0 mg/l.

In Table IX-3 in Appendix IX, the applicant used a mathematical approach to compute the dissolved oxygen depletions due to both undisturbed sediments and disturbed sediments. The applicant does not follow the guidelines contained in the Technical Support Document (EPA 1979) which specify using the bottom 2 m (6.6 ft) of the water column for determining dissolved oxygen depletion. Rather, the applicant uses the entire depth of water and determines the depletion at the ocean bottom relative to the depletion at the water's surface.

The applicant equates the downward flux of oxygen and the sediment oxygen uptake and concludes that the oxygen depletion due to a steady demand is 0.05 mg/l, and the depletion due to an abrupt demand is 0.5 mg/l. Since an error has been found in the applicant's work, the analyses are repeated here in some detail.

The downward flux of oxygen due to turbulent diffusion is:

$$F = -K \frac{dc}{dy}$$

where:

F = downward flux of oxygen, $g/m^2/sec$

K = turbulent diffusion coefficient, m^2/sec

$\frac{dc}{dy}$ = vertical oxygen concentration gradient, g/m^4.

At steady state the flux F equals the sediment oxygen demand if all other processes affecting the dissolved oxygen concentration can be ignored. The applicant's approach assumes that such a situation is true. This approach is equivalent to assuming that the current speed of the ambient water over the waste field is zero for a prolonged period of time. Further, it also assumes that there is no horizontal exchange between the water over the waste field and the remaining oceanic water. The only mechanism replenishing dissolved oxygen at depth is vertical diffusion. Such a hypothetical situation may predict conservatively high oxygen depletions.

The oxygen depletion predicted using this approach is:

$$\Delta DO = \frac{S_B(h-z)}{K}$$

where:

S_B = sediment oxygen demand $g/m^2/day$

ΔDO = difference in dissolved oxygen concentration at depths z and h, mg/l

h = water depth, m

z = distance, measured from the water surface downward.

The applicant does not explicitly use the above equation, but it is instructive to present the applicant's equation (d), Table IX-3, in this form. This expression shows that the change in dissolved oxygen is inversely proportional to K. In the applicant's analyses, z is set equal to zero so that the dissolved oxygen gradient is over the entire water depth. Including z in the equation adds generality so that other situations can be evaluated.

The expression for the vertical turbulent diffusion coefficient used by the applicant shows that K is inversely proportional to the density gradient. The formula reported by the applicant is:

$$K = \frac{10^{-4}}{\frac{1}{\rho}\frac{d\rho}{dy}}$$

where:

ρ = ambient water density, g/cm^3

$\frac{d\rho}{dy}$ = density gradient, g/cm^4.

The applicant erroneously reports that y is measured in centimeters, while it should actually be measured in meters. The applicant carries this mistake through the dissolved oxygen calculations (as will be shown). The correct expression for K (Koh and Brooks 1975) is as follows (in the mks system of units):

$$K = \frac{10^{-8}}{\frac{1}{\rho}\frac{d\rho}{dy}}$$

Based on the critical density profile, the vertical turbulent diffusion coefficient is as follows:

$$K = \frac{10^{-8}}{\frac{1}{1,024} \times \frac{3.1}{22}} = 0.7 \times 10^{-4}\ m^2/sec = 0.7\ cm^2/sec.$$

The applicant apparently uses a turbulent diffusion coefficient of 70 cm^2/sec, which is toward the upper end of those reported in the literature (Koh and Brooks 1975) and is certainly not appropriate for the critical conditions analyzed here. Inserting the applicant's data in the expression for the dissolved oxygen gradient, the following dissolved oxygen difference is calculated:

$$\Delta DO = \frac{1.3 \times 22}{70} \times \frac{1}{10^{-4}\ m^2/cm} \times \frac{1}{86,400\ sec/day} = 0.05\ mg/l.$$

Using the smaller (and more correct) diffusion coefficient, the oxygen difference would be:

$$\Delta DO = 5 \text{ mg/l}.$$

Based on a minimum ambient dissolved oxygen concentration of 6.5 mg/l, the dissolved oxygen concentration at the bottom of the water column would be 1.5 mg/l.

The applicant extends this approach to calculate oxygen depletion due to abrupt resuspension of sediments by increasing the oxygen depletion rate by a factor of 10. The applicant predicts a depletion of 0.5 mg/l (which is based on the erroneous diffusion coefficient). Employing the smaller diffusion coefficient, the difference calculated by this method would be 50 mg/l. Hence, the applicant's approach predicts that vertical turbulent diffusion alone cannot supply oxygen at a rate fast enough to prevent at least part of the water column from completely deoxygenating. Other processes which the applicant ignores (e.g., advection) could prevent this severe depletion.

The intent of the EPA, as outlined in the Technical Support Document (EPA 1979), is to evaluate the impact of bottom sediments on the dissolved oxygen resources of the bottom 2 m (6.6 ft) of the water column. If the applicant's procedure is revised, but only the bottom 2 m (6.6 ft) of the water column are assumed to be influenced by the sediment oxygen demand (h - z = 2 in the expression presented earlier), then the oxygen depletion (using the proper diffusion coefficient) is as follows:

$$\Delta DO = \frac{1.3 \times 2}{0.7} \times \frac{1}{10^{-4}\ m^2/cm^2} \times \frac{1}{86{,}400\ sec/day} = 0.4\ mg/l.$$

For this approach to be valid the vertical diffusion rate at 2 m (6.6 ft) or more above the bottom would have to greatly exceed the diffusion rate in the bottom 2 m (6.6 ft), so that the effect of the oxygen depletion is felt only in the bottom 2 m (6.6 ft).

The sediment oxygen demand used in these calculations is 1.3 $g/m^2/day$, which the applicant reports is in the range of 0.95 to 1.69 $g/m^2/day$ measured for undisturbed sediments in the Charles River. This is also within the range of results of other researchers such as Pamatmat and Banse (1969), who found oxygen uptake rates in Puget Sound to be from 0.14 to 1.4 $g/m^2/day$. However, the incremental sediment oxygen demand associated with the outfall appears to be less than 1.3 $g/m^2/day$, as is shown on the following pages.

As an alternative to the applicant's approach, the oxygen depletion in the bottom 2 m (6.6 ft) of the water column due to a steady demand of sediments is calculated by assuming the water column to be mixed over the bottom 2 m (6.6 ft) and by ignoring any further dilution processes as the water is advected across the sedimentation field. The elevated benthic oxygen demand is estimated based on the deposition and decay of suspended solids. The oxygen depletion predicted by this method is given by the expression:

$$\Delta DO = \int_0^{X_m} \frac{S_B \, dx}{HU} = \frac{(S_{B2} + S_{B1}) \, X_m}{2 \, UH}$$

where:

S_B = benthic oxygen demand caused by outfall-related sedimentation, assumed to be a linear function of distance from the diffuser, x

S_{B1} = sediment oxygen demand of sediments near diffuser

S_{B2} = sediment oxygen demand of sediments at far end of sedimentation area

H = depth of water over which oxygen demand is exerted (taken to be 2 m)

U = current velocity

X_m = length of sedimentation area.

The benthic oxygen demand is calculated from the steady-state concentration of deposited organic material. The steady-state concentration of organic matter (C) is estimated as:

$$C = \frac{M}{A} \times \frac{1}{k_d}$$

where:

$\frac{M}{A}$ = seabed deposition rate

k_d = decay rate of settled material.

Based on the maximum and minimum deposition rates of 500 g/m^2/yr and 125 g/m^2/yr, respectively (see Part B, Section 4, Seabed Accumulation), the steady-state concentrations of settled solids become 140 g/m^2 and 30 g/m^2. A decay rate of 0.01/day (Chen et al., 1975) is used.

The stoichiometric oxygen/sediment equivalent is approximately 1:1 (Zison et al., 1978). This figure is probably an overestimate for sediments which have been deposited on the ocean floor for a period of time. One 301(h) applicant has experimentally measured the BOD of settled materials and found a value of 0.1:1 (Commonwealth of Massachusetts, Metropolitan District Commission 1979). Using this value as a best guess and a decay rate of 0.01/day, the benthic oxygen demands become:

$$S_{B1} = 140 \times 0.01 \times 0.1 = 0.14 \text{ g/m}^2\text{/day}$$

$$S_{B2} = 30 \times 0.01 \times 0.1 = 0.03 \text{ g/m}^2\text{/day.}$$

Using the net drift current of 2.2 cm/sec (0.07 ft/sec) and the length of the waste field of 3.5 km (2.2 mi), the oxygen depletion is:

$$\Delta DO = \frac{(0.14 + 0.03)\ 3,500}{2 \times 0.022 \times 2 \times 86,400} = 0.1\ mg/l.$$

This depletion is less than that calculated using the applicant's formula correctly. It is notable that the review of Part B, Section 4, Seabed Accumulation, uncovered a number of weaknesses in the applicant's approach to predicting seabed deposition, so the above result should be considered as an upper limit estimate.

The depletion of dissolved oxygen due to an abrupt resuspension of sediments was calculated by the applicant and, when using the proper units for the diffusion coefficient, is 50 mg/l. This is an unrealistic prediction due to several reasons previously discussed. According to the guidelines in the Technical Support Document (EPA 1979), the oxygen depletion due to an abrupt resuspension of sediment is to be determined based on resuspension of sediment that have accumulated for 90 days. The resuspension is assumed to occur over the bottom 2 m (6.6 ft) of water and the depletion is calculated over a 24-h period.

To determine the 90-day supply of sediment available for resuspension, the applicant's seabed accumulation predictions shown in Part B, Section 4, are used. For the purpose at hand, solids which accumulate at the rate of 500 $g/m^2/yr$ will be resuspended to a depth of 2 m (6.6 ft). The resulting concentration of suspended solids is:

$$\frac{500\ g/m^2/yr}{2\ m} \times \frac{90\ days}{365\ days/yr} = 60\ mg/l.$$

Using a 0.1:1 equivalence of BOD:sediments, this concentration of suspended solids is equivalent to a BOD of:

$$60 \times 0.1 = 6 \text{ mg/l, BOD-ultimate.}$$

Assuming a decay rate of 0.1/day for the resuspended materials (Chen et al., 1975), the 24-h oxygen depletion is:

$$6 \text{ mg/l} \times 0.1\text{/day} = 0.6 \text{ mg/l, in 24 h.}$$

To summarize, the farfield oxygen depletions calculated in this review are (all are worst cases):

- 0.7 mg/l, due to BOD exertion in the water column based on the existing level of treatment; 0.5 mg/l based on 30 percent BOD removal.

- 0.1 to 0.4 mg/l in the bottom 2 m, due to a steady benthic oxygen demand.

- 0.6 mg/l in the bottom 2 m in 24-h, due to an abrupt resuspension of sediments.

Only if the ambient dissolved oxygen concentration drops below 6.7 mg/l will violations of the state standard of 6.0 mg/l probably occur.

Oxygen Demand in Bottom 2 m of Water Column--

The previous question analyzed the oxygen depletion in the bottom 2 m (6.6 ft) of the water column. The applicant does not provide specific data for the critical dissolved oxygen concentrations in the bottom 2 m (6.6 ft).

Frequency of Exceedance of Dissolved Oxygen Criteria--

Based on the analyses performed in reviewing the previous questions, it does not appear that the state dissolved oxygen criteria can be violated unless the ambient concentration falls below 6.7 mg/l. At the proposed diffuser site the minimum observed value has been 7.1 mg/l, based on 2 days of sampling. If the dissolved oxygen concentration should drop to 6.7 mg/l and if the critical conditions analyzed previously were to occur, then it is conceivable that the state standards could be violated for the existing level of treatment. The probability of this situation occurring appears low.

More Critical Evaluation of Dissolved Oxygen Depletion--

The applicant believes that the most critical situations with respect to oxygen depletion have been addressed. In cases where this is not true, this review has tried to address the more critical situations.

There are several additional possibilities which could lead to more critical situations. They are the following:

- The effects of current reversals are not considered in these analyses. Current reversals could tend to cause build-up of oxygen-demanding materials to levels higher than those analyzed in this document.

- In the analysis of oxygen depletions due to BOD exertion, the applicant does not consider the exertion due to nitrogenous BOD (NBOD). NBOD has a potential for exerting an oxygen demand in a manner similar to the carbonaceous BOD. Often, however, a lag of 5 or more days occurs before this depletion begins to be realized. If such a 5-day lag were to occur, the additional oxygen depletion would be negligible because by that time the effluent would be significantly diluted. If the NBOD were to be exerted immediately, an incremental oxygen depletion would occur. However, data are not available to assess this possible impact. As a worst case, the additional oxygen demand would probably not exceed that caused by carbonaceous BOD. This assumes that the NBOD and CBOD concentrations in the wastewater are the same and depletion rates are the same.

Section 3. Compliance with pH

Effluent Characteristics--

The effluent from the New Bedford treatment plant does not meet the criteria of 40 CFR 133.102(c) which specify that the pH of the effluent must not drop below 6.0 or exceed 9.0. The applicant lists the pH values for the 7 days when these limits were exceeded during the period July, 1978, to June, 1979. Data from the NPDES discharge monitoring reports (Table 18) show that the pH of the effluent has been between 3.3 and 9.9 for the period January, 1978, through February, 1981. The number of days when the minimum limit of 6.0 was not met was 15 days in 1978, 8 in 1979, 78 in 1980, and 1 in January and February, 1981. The maximum limit of 9.0 was exceeded once in 1979 and once in 1981. The applicant attributes the problem to the industrial wastewater component, although no description of the type of industry or wastewater characteristics are given. Based on the observed low effluent pH values which are not accompanied by low influent pH values the operation of the treatment plant may be contributing to the low effluent pH.

State Standard--

The proposed outfall will discharge into Buzzards Bay, which is designated Class SA waters by Massachusetts. The receiving water standard for pH specifies that the pH be between 6.5 and 8.5 and not more than 0.2 units outside of the naturally occurring range.

TABLE 18. pH DATA FOR PRESENT NEW BEDFORD TREATMENT PLANT

Year	Month	Influent pH Min	Influent pH Max	Effluent pH Min	Effluent pH Max	Days <6	Days >9
1978	January	3.4	8.6	3.6	7.9	5	0
	February	6.6	8.7	4.3	7.7	6	0
	March	6.3	8.3	4.9	7.4	2	0
	April	7.0	8.7	6.4	7.6	0	0
	May	3.7	8.4	6.5	7.5	0	0
	June	3.5	8.1	4.7	7.5	1	0
	July	7.0	7.8	6.8	7.8	0	0
	August	-	-	-	-	-	-
	September	-	-	-	-	-	-
	October	6.8	8.5	5.7	7.4	1	0
	November	6.5	7.8	6.4	7.4	0	0
	December	5.7	7.6	6.7	7.4	0	0
1979	January	6.5	7.4	5.1	7.2	2	0
	February	6.3	8.2	6.5	7.5	0	0
	March	6.5	7.8	5.7	9.1	1	1
	April	6.7	7.8	3.3	7.4	3	0
	May	5.8	7.3	6.7	7.4	0	0
	June	6.8	7.4	5.3	7.3	2	0
	July	6.6	7.5	6.2	7.2	0	0
	August	6.8	8.1	6.0	7.9	0	0
	September	6.8	7.4	6.3	7.4	0	0
	October	3.9	8.0	6.1	7.1	0	0
1980	January	6.1	9.1	6.1	7.2	0	0
	February	5.5	8.5	5.2	8.1	3	0
	June	5.6	7.3	5.3	7.0	10	0
	July	6.1	7.0	5.6	6.4	6	0
	August	5.3	6.8	3.8	6.4	16	0
	September	5.4	6.6	5.4	6.4	16	0
	October	4.4	7.5	4.0	6.6	15	0
	November	5.9	7.3	5.4	6.8	12	0
	December	6.3	7.6	6.0	7.2	0	0
1981	January	6.0	7.2	5.4	9.9	1	1
	February	6.3	7.4	6.5	6.8	0	0

pH of the Effluent-Seawater Mixtures--

The applicant did not test mixtures of effluent and seawater for pH because low effluent pH values did not occur during the time when the application was prepared.

Compliance with Receiving Water pH Standards--

The applicant states that because of the high initial dilution and large buffering capacity of seawater, the state standard should be met at the ZID boundary.

Receiving water pH data for July 31, 1979, at several stations near the existing discharge shown in Figure 14 were between 8.0 and 8.1. Data at three stations near the proposed outfall also shown in Figure 14 had a pH range of 6.6 to 10.1 for the period November, 1975, through April, 1976. A pH model was used to predict whether the extreme effluent pH conditions would cause the state standard to be violated. Based on the lowest initial dilution of 59:1, a receiving water pH of 8.5, and the extreme case of effluent pH equal to 9.9, the state standard would not be violated. At low receiving water pH conditions, the state standard would be violated if the effluent pH dropped to 3.3 and the receiving water pH was 6.6. The state standard would be met as long as the effluent pH is above 4.0. Values below 4.0 have occurred three times from January, 1978, through February, 1981.

Further Considerations Regarding pH--

The applicant did not present any other information. The extreme cases analyzed above are believed to represent the most critical situations.

Section 4. Compliance with Suspended Solids

Introduction--

The effluent from the New Bedford treatment plant currently exceeds the suspended solids criteria for secondary treatment and is expected to exceed the criteria following the achievement of an improved discharge. As set forth in 40 CFR 133.102(b), these criteria call for a suspended solids removal efficiency of 85 percent or greater, and 7-day and 30-day maximum effluent suspended solids levels of 45 mg/l and 30 mg/l, respectively. According to its NPDES permit application, the New Bedford treatment plant will achieve an average suspended solids removal efficiency of 50 percent, and will discharge an effluent with an annual average of 50 mg/l suspended solids.

Adjusted Suspended Solids Requirements--

The applicant has not received and is not in the process of receiving an adjusted suspended solids requirement.

Receiving Water Suspended Solids Standards--

The state of Massachusetts has no quantitative receiving water standard for suspended solids or for surrogate measures such as turbidity or transparency. As cited by the applicant, the pertinent qualitative standard states that "color, turbidity, total suspended solids shall not be in concentration or combination that would exceed the recommended limits on the most sensitive receiving water use." The waters in the area of the proposed outfall are Class SA, meaning they are designated for the protection and propagation of fish, other aquatic life, and wildflife; for primary and secondary contact recreation; and for shellfish harvesting without depuration in approved areas. In Part A, Section 9, the applicant also lists several general aesthetic criteria for receiving waters which are set forth in Massachusetts State law. These are that "All waters shall be free from pollutants in concentrations or combination that

a) settle to form objectionable deposits;

b) float as debris, scum or other matter to form nuisances; or

c) produce objectionable odor, color, taste or turbidity."

Effluent Suspended Solids--

In Question B1-3 the applicant identified mid-summer as the critical period with respect to dilution of the effluent. Minimum, average, and maximum hourly flows for this period were derived from July, 1979, treatment plant monitoring data. In the present section the applicant has, as requested, provided effluent suspended solids concentrations corresponding to these flows. For minimum, average, and maximum hourly flows, the effluent concentrations provided are 84, 136, and 110 mg/l, respectively. Since these concentrations correspond to hourly flows, they cannot be verified by checking against the effluent monitoring reports, which list only one effluent suspended solids level per day. However, it is worthwhile to review the monitoring reports. Table 19 shows the minimum, average, and maximum daily values measured for each month in 1979 and 1980. These values have a much wider range than those reported by the applicant for the various hourly flow conditions. During these 2 years, monthly minima of less than 50 mg/l were recorded several times. In the July-August critical period, the average monthly suspended solids level ranged from 156 to 193 mg/l in 1979 and 1980. Over the entire 2-year period, monthly maxima of more than 300 mg/l were common, and effluent suspended solids levels greater than 500 mg/l were recorded four times. A check of the flow records shows that these incidents occasionally corresponded to times of very high flow, presumably due to stormwater runoff. Also, effluent suspended solids levels frequently exceeded influent levels when the flows were within the design capacity of the treatment plant.

Projections of future effluent suspended solids concentrations have been made based on the design removal efficiency of 50 percent (Table 20). The average suspended solids concentration would be 63 mg/l with a monthly range of approximately 37 mg/l to 115 mg/l. If the effluent suspended solids concentration of 50 mg/l is assumed, the removal efficiency would have to average 56 percent and would have to be as high as 78 percent in some months (Table 20).

TABLE 19. DAILY SUSPENDED SOLIDS VALUES IN THE NEW BEDFORD PRIMARY EFFLUENT, 1979-1980

Month	1979 Minimum	1979 Average	1979 Maximum	1980 Minimum	1980 Average	1980 Maximum
January	32	84	188	30	120	406
February	44	85	208	42	122	288
March	16	84	228	a	129	378
April	40	112	334	a	101	244
May	56	93	238	a	111	214
June	50	144	376	46	107	156
July	28	156	670	60	193	480
August	28	186	720	84	166	576
September	18	147	344	48	174	976
October	64	144	366	24	102	220
November	a	120	350	68	141	304
December	a	104	232	12	124	200

[a] Data not available.

Note: All units are mg/l.

Source: Data are from the NPDES discharge monitoring reports.

TABLE 20. PROJECTED SUSPENDED SOLIDS CONCENTRATIONS AFTER PLANT MODIFICATION

Year	Month[a]	Average Influent (mg/l)	Average Effluent[b] (mg/l)	Removal Efficiency[c]
1979	January	75	38	33
	February	90	45	44
	March	78	39	36
	April	95	48	47
	May	74	37	32
	June	106	53	53
	July	174	87	71
	August	140	70	64
	September	144	72	65
	October	106	53	53
1980	January	98	49	49
	February	116	58	57
	June	107	54	53
	July	136	68	63
	August	160	80	69
	September	142	71	65
	October	150	75	67
	November	170	85	71
	December	230	115	78
	Average	126	63	56

[a] Several months were not available.

[b] Calculated effluent concentration based on the design removal efficiency of 50 percent.

[c] Calculated removal efficiency based on the appliant's projected effluent concentration of 50 mg/l.

Final Suspended Solids Following Initial Dilution--

In calculating final suspended solids following initial dilution, the applicant utilizes ambient suspended solids values of 2 and 4 mg/l. These are derived from data taken in New Bedford Harbor in 1975 and 1976 (Ellis et al., 1977). All of the stations occupied in that survey were inshore of the proposed outfall; the deepest water sampled was 10.3 m (34 ft) deep. Table 21 shows suspended solids data taken at the stations nearest the proposed outfall site. The stations are shown on Figure 15. Suspended solids levels at these stations ranged from 0.36 to 6.1 mg/l. No regular pattern of increase or decrease in solids with depth can be seen. There are no summer data, but late April values ranged from 0.8 to 2.5 mg/l. These two values will be used in this evaluation, with 0.8 mg/l ambient suspended solids representing the summer "worst case" condition.

In calculating final suspended solids, the single initial dilution value of 76 is used by the applicant; this is judged to represent the most critical condition. This evaluation will use the minimum, average, and maximum flow dilutions shown in Table 9.

The calculation of final suspended solids following intial dilution is made by the following formula:

$$C_f = C_a + \left(C_e - C_a\right) / S_a$$

where:

TABLE 21. SUSPENDED SOLIDS MEASUREMENTS MADE IN NEW BEDFORD HARBOR

Sampling Date	Station	Water Depth m	Water Depth (ft)	Sampling Depth[a] m	Sampling Depth[a] (ft)	SS (mg/l)
11/24/75	H-1	8.5	(28)	S	S	1.2
				6.7	(22)	1.4
				7.9	(26)	2.7
	H-1	8.8	(29)	S	S	1.2
				7.3	(24)	1.5
				8.5	(28)	2.6
11/26/75	P-11	10.0	(33)	S	S	1.9
				5.5	(18)	2.8
				8.5	(28)	1.6
				9.7	(32)	1.5
1/6/76	P-11	10.0	(33)	S	S	1.4
				5.4	(18)	0.36
				8.5	(28)	3.3
				9.7	(32)	4.2
1/7/76	P-11	9.4	(31)	S	S	1.3
				4.8	(16)	1.0
				9.1	(30)	4.8
3/9/76	P-11	10.0	(33)	S	S	5.6
				8.2	(27)	4.8
				9.7	(32)	6.1
4/28/76	P-11	9.4	(31)	S	S	2.5
				7.9	(26)	2.2
				9.1	(30)	1.8
4/29/76	P-11	9.4	(31)	S	S	1.2
				9.1	(30)	2.8
4/30/76	P-11	10.3	(34)	S	S	0.86
				8.8	(29)	0.82
				8.8	(29)	1.4

[a] "S" denotes a surface sample.

Source: Ellis et al. (1977).

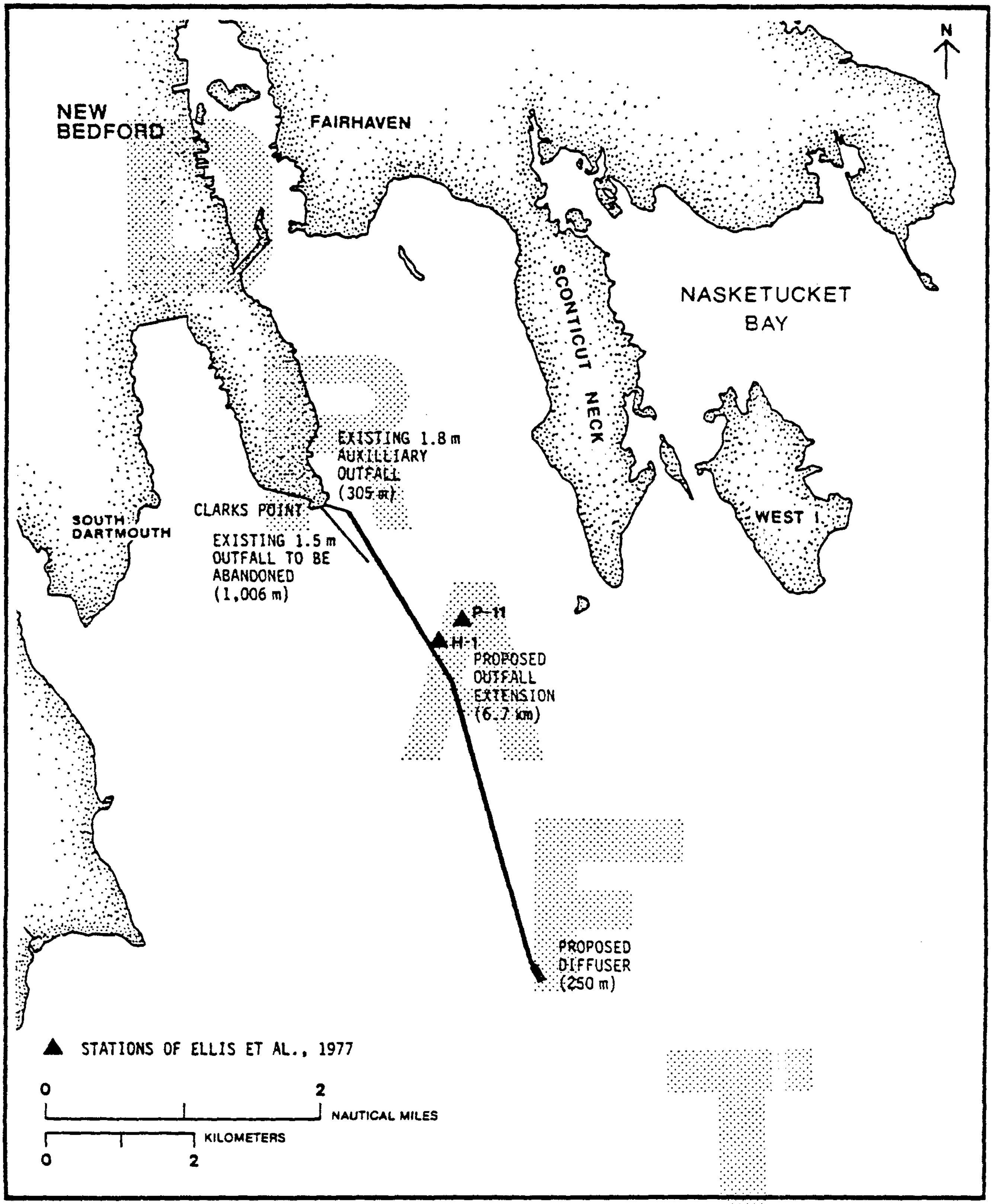


Figure 15. Site of ambient suspended solids measurements taken in 1975 - 1976, New Bedford, MA.

C_f = final suspended solids, mg/l

C_a = ambient suspended solids, mg/l

C_e = effluent suspended solids, mg/l

S_a = initial dilution.

The results of the applicant's calculation, and those of this evaluation, are shown in Table 22. Given the applicant's initial values, final suspended solids levels of 3.8 mg/l and 5.7 mg/l were correctly calculated for waters having ambient concentrations of 2 and 4 mg/l, respectively. These final concentrations are 1.8 and 1.7 mg/l greater than the assumed ambient concentrations, and are within the range of values observed at the shallower stations (see Table 21). When average observed summer effluent suspended solids levels are used with the dilutions of this review, higher final suspended solids levels (3.5 to 6.9 mg/l) are derived. At the highest summertime effluent level, under maximum flow conditions, final suspended solids levels of 17.7 and 19.7 mg/l are predicted. Those represent increases of 15.7 mg/l over the low and high ambient levels used by the applicant.

Based on the projected effluent conditions, final suspended solids levels are predicted to be between 3 and 5 mg/l under average effluent levels and 3.9 and 5.9 mg/l under maximum effluent levels. Thus, the

TABLE 22. FINAL SUSPENDED SOLIDS FOLLOWING INITIAL DILUTION, NEW BEDFORD, MA, EFFLUENT[a]

		Flow condition					
		Minimum[a]		Average[b]		Maximum[d]	
	SS_e	Low SS_a	High SS_a	Low SS_a	High SS_a	Low SS_a	High SS_a
Application	136	-		-		3.8	5.7
Review[e]	28	2.2	4.2	2.3	4.2	2.4	4.4
	175	3.5	5.5	4.3	6.3	4.9	6.9
	720	8.4	10.4	11.6	13.6	14.2	16.2
	926	10.3	12.2	14.4	16.4	17.7	19.7
Projected Conditions[f]	37	2.3	4.3	2.5	4.4	2.6	4.6
	63	2.5	4.5	2.8	4.8	3.0	5.0
	115	3.0	5.0	3.5	5.5	3.9	5.9

[a] All units are mg/l.

[b] Review initial dilution = 112 (see Table 9).

[c] Review initial dilution = 74.4.

[d] Review initial dilution = 58.7.

[e] Effluent values are the minimum, average, and maximum values for July and August, 1979 and 1980. The value of 926 is the minimum recorded value for 1979 and 1980 (Table 19).

[f] Effluent values are the minimum, average, and maximum concentrations from Table 20.

maximum increase above ambient levels of 2.0 and 4.0 mg/l is 1.9 mg/l. Also, ambient suspended solids levels less than those utilized herein may occur at the proposed outfall site, in water 15 m (49 ft) deep. Thus, conditions more "critical" than those analyzed herein might occasionally exist.

Compliance with State Suspended Solids Standards--

Massachusetts does not have a quantitative standard for suspended solids concentrations in ocean waters.

Compliance with Surrogate Suspended Solids Standards--

As previously discussed, the water clarity standard is qualitative, specifying only that turbidity and total suspended solids may not be present "...in concentration or combination that would exceed the recommended limits on the most sensitive receiving water use." The applicant has made no assessment of the effluent quality relative to this standard, and the application does not include an Appendix VIII.

Shellfish harvesting and primary contact recreation are the two most sensitive uses for which Class SA waters are designated by Massachusetts. Neither the state of Massachusetts nor the U.S. Environmental Protection Agency has recommended quantitative limits on the suspended solids concentrations of waters used for these purposes. Federal policy is that "Individual waters vary in the natural amounts of suspended sediments they carry; therefore, no fixed recommendation can be made. Management decisions should be developed with reference to historical base line data concerning the individual...water" (National Academy of Sciences 1972). The increases in final suspended solids projected herein for the proposed outfall are within the range of natural variation observed for waters somewhat inshore of the site (Ellis et al., 1977). For this reason, and because of the general nature of the state standard, compliance of the proposed outfall with the suspended solids standard cannot be firmly assessed.

Seabed Accumulation--

The applicant predicts seabed accumulation rates around the proposed New Bedford diffuser, which extends 7,010 m (23,000 ft) into Buzzards Bay. The predicted deposition rates do not consider the effects of sediment decay or resuspension. The applicant does provide discussions of the propensity of settled materials to be resuspended and the effective lower limit of particle fall velocity but does not use the information in a quantitative sense.

The solids deposition pattern predicted by the applicant is shown in Figure 16. The applicant's original figure (Figure IX-3) depicts depositional contours in units of mm/yr. They have been converted to units of $g/m^2/yr$ here by utilizing the applicant's assumption that the seabed deposits are 4 percent solids.

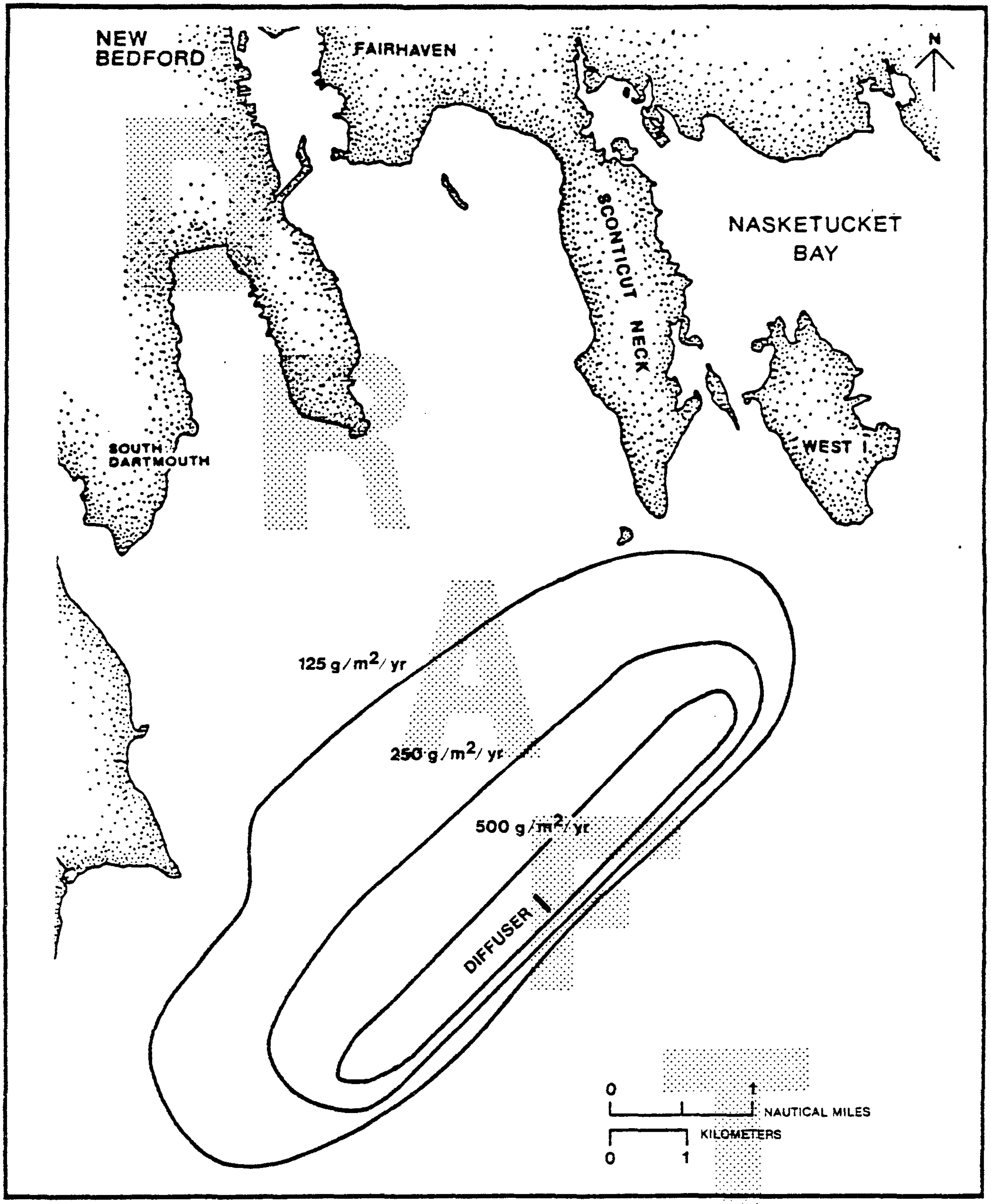


Figure 16. Solids deposition pattern predicted by applicant New Bedford, MA, treatment plant.

The predicted deposition area lies to the northwest of the proposed diffuser and extends 3.7 km (2.3 mi) in that direction to the 125 $g/m^2/yr$ contour. More detailed characteristics of the deposition area are presented in Table 23. The maximum predicted deposition rate is 513 $g/m^2/yr$. The minimum deposition rate is 125 $g/m^2/yr$. Approximately 100 percent of the discharged suspended solids are predicted to settle within the latter contour.

For this review, the following aspects are examined:

- Location of predicted deposition area
- Approach used to predict deposition rates
- Settling velocity distribution
- Mass emission rate of suspended solids
- Lower limit of particle settling velocity
- Resuspension of sediments.

The concept used by the applicant to predict the boundaries of the deposition area is based on the motion of the sea during the incoming and outgoing tides. Figure 11, taken from the applicant's Figure B-5, illustrates this concept. During the incoming tide, the waste field is

TABLE 23. SUSPENDED SOLIDS MASS EMISSION RATE AND APPLICANT'S PREDICTED SEABED ACCUMULATION RATES - PROPOSED NEW BEDFORD, MA, OUTFALL

Total Suspended Solids Mass Emission Rate (MER)	
kg/day (lb/day)	19,100 (42,200)
Maximum Deposition	
- Rate ($g/m^2/yr$)	513
- Depth [cm/yr (in/yr)]	1.3 (0.5)[a]
- Bottom area	Unknown
Maximum Contour Deposition[b]	
- Rate ($g/m^2/yr$)	500
- Depth [cm/yr (in/yr)]	1.3 (0.5)[a]
- Bottom area [km^2 (mi^2)]	5.0 (1.9)
- MER within this contour kg/day (lb/day)	6,800 (15,000)
- Percent of total MER within this contour	35
Minimum Contour Deposition[c]	
- Rate ($g/m^2/yr$)	125
- Depth [cm/yr (in/yr)]	0.3 (0.1)[a]
- Bottom area [km^2 (mi^2)]	33 (13)
- MER within this contour kg/day (lb/day)	19,100 (42,000)
- Percent of total MER within this contour	100
Settling Velocity Distribution	
cm/sec (ft/h)	1 percent exceed 0.18 (21), 55 percent exceed 0.006 (0.7)

[a] The applicant computes these depths based on 4-percent solids content.

[b] These figures represent the highest deposition rates presented by the applicant in Figure 16.

[c] These figures represent the lowest deposition rates presented by the applicant in Figure 16.

transported to the northeast one tidal excursion; during the outgoing tide, the waste field is transported to the southwest the same distance. At the same time, there is a net onshore drift of water which transports the sediments to the northwest of the diffuser. The applicant's predicted deposition area shown in Figure 16 qualitatively agrees with this description.

The current data used to generate the contours shown in Figure 16 were collected over a 1-month period in July and August, 1979. Based on this limited data base, it is not certain that the predicted deposition pattern is really typical of longer term conditions, or even of summer months during other years. By assuming that the currents, on an annual basis, remain the same as during the oceanographic survey period, the applicant's prediction might overestimate deposition rates and underestimate the spatial extent of the deposition area.

The applicant's procedure also does not consider that the tidal excursion and net drift velocity might change in both magnitude and direction as functions of distance from the proposed outfall site. Because the net drift direction is shoreward, spatial variations in current patterns are likely to be present. Figures 9 and 10 shown earlier illustrate these differences.

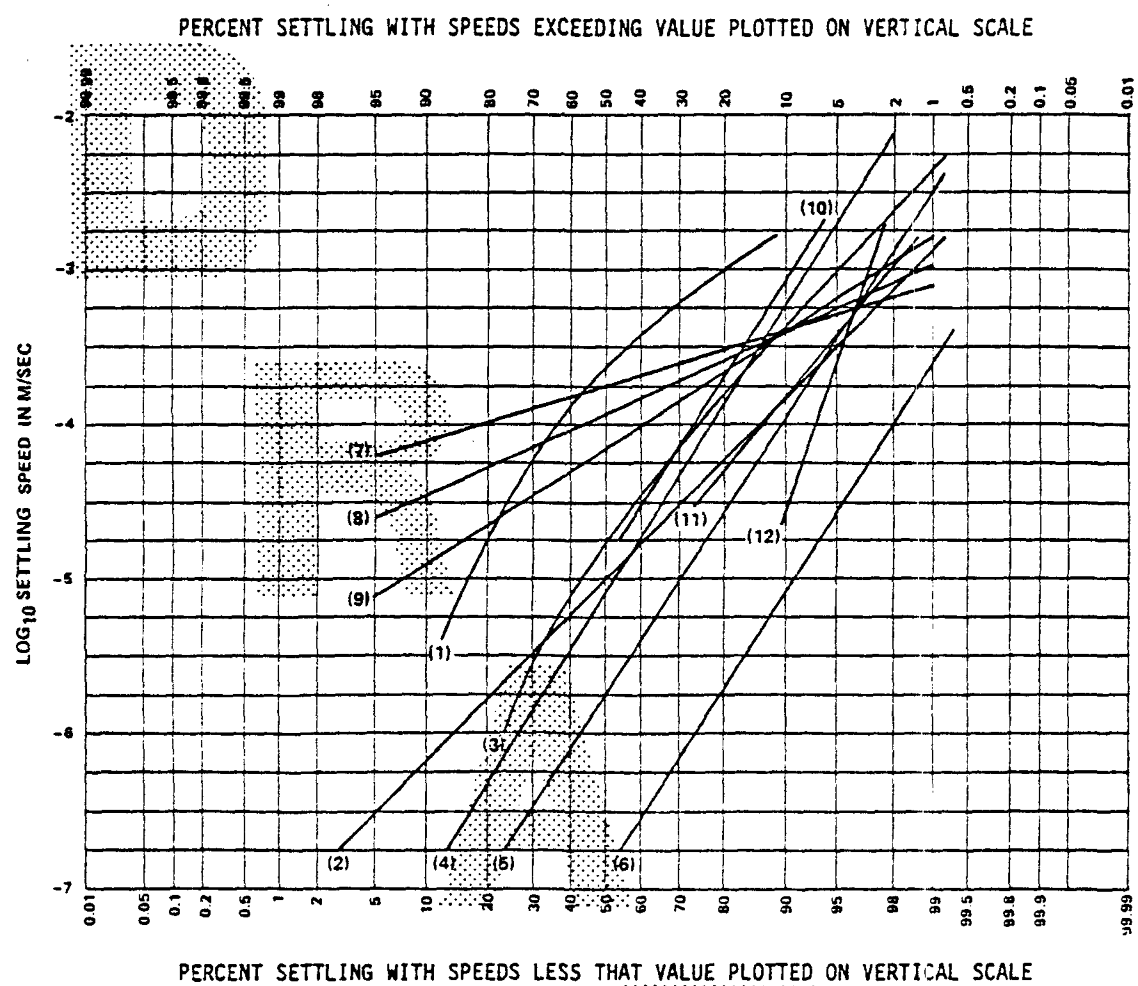
To predict the gradient of deposited sediments in the direction of net drift, the applicant uses a mathematical approach which relates the distance a particle travels from the outfall before settling (r) as a function of net drift velocity (u), the height of rise of the plume (h), and the settling velocity of the particles (w). Each of the three independent variables (u, h, w) is assumed to be log-normally distributed, so that r is also log-normally distributed. The applicant relates these variables as follows:

$$r = \frac{uh}{w}.$$

This relationship assumes that u is not a function of time and is apparently one reason the applicant uses u for net drift speed. However, by using this approach, the applicant is unable to predict concentration gradients in the direction normal to the net drift. The seabed accumulation contours assume the shape of approximate rectangles (see Figure 16). In reality, there is probably enhanced settling toward the centerline of the deposition area and depressed accumulation rates near the lateral boundaries.

The applicant does not make direct measurements of settling speeds of the suspended solids but rather employs the following procedure. First, settling speed curves obtained from the literature are plotted as shown in Figure 17. These curves are numbered (1) through (6). From these curves the standard deviations of the natural logarithms of the settling speed distributions (σ_r) are obtained. This range of σ_r's is assumed to represent the raw influent. The applicant then relates the settling speeds of the raw influent to the primary-treated effluent as follows:

$$w_{90} = W_{40}$$



1) BROOKS: Digested Sludge in seawater, 20:1
2) MYERS: Primary Effluent and Sludge Centrate in seawater, 1:1
3) FAISST: Sludge in seawater, 50:1
4) FAISST: Sludge in seawater, 100:1
5) FAISST: Sludge in seawater, 500:1
6) MOREL: Effluent in NaCl
7) $\sigma_{prim} = 0.75$ }
8) $\sigma_{prim} = 1.10$ } RANGE OF SETTLING DISTRIBUTIONS ASSUMED FOR PRIMARY EFFLUENT
9) $\sigma_{prim} = 1.60$ }
10) ORANGE CO.,CA. (Herring and Abati, 1978)
11) PT. LOMA, CA. (Herring and Abati, 1978)
12) HYPERION, CA. (Herring and Abati, 1978)

REFERENCE: REDRAWN FROM FIGURE IX-1, NEW BEDFORD 301(h) APPLICATION, 1979

Figure 17. Settling velocity distributions, New Bedford, MA, treatment plant.

$$w_{50} = W_{22}$$

where:

w_{90} = 90-percentile settling speed of treated effluent

w_{50} = 50-percentile settling speed of treated effluent

W_{40} = 40-percentile settling speed of raw wastewater (taken to be overflow rate of primary clarifier)

W_{22} = 22-percentile settling speed of raw wastewater.

Based on these relationships, the applicant generates the three settling speed curves in Figure 17 [Curves (7), (8), and (9)]. Curve (9) (the lower of the three curves) is used to generate the seabed deposition rates shown in Figure 16.

Since the applicant's approach is a mathematical one and does not use experimental data, it is worthwhile to examine the sensitivity of the curves to some of the assumptions the applicant makes. First, the applicant uses the clarifier overflow rate as the 90-percentile settling velocity of the treated effluent. The settling velocity so determined, however, neglects the altered settling that could occur when effluent and seawater are mixed. Second, the applicant sets

$$w_{90} = W_{40}$$

for "practical considerations." Theoretically, however, the following relationship is more appropriate:

$$w_{100} = W_{40}.$$

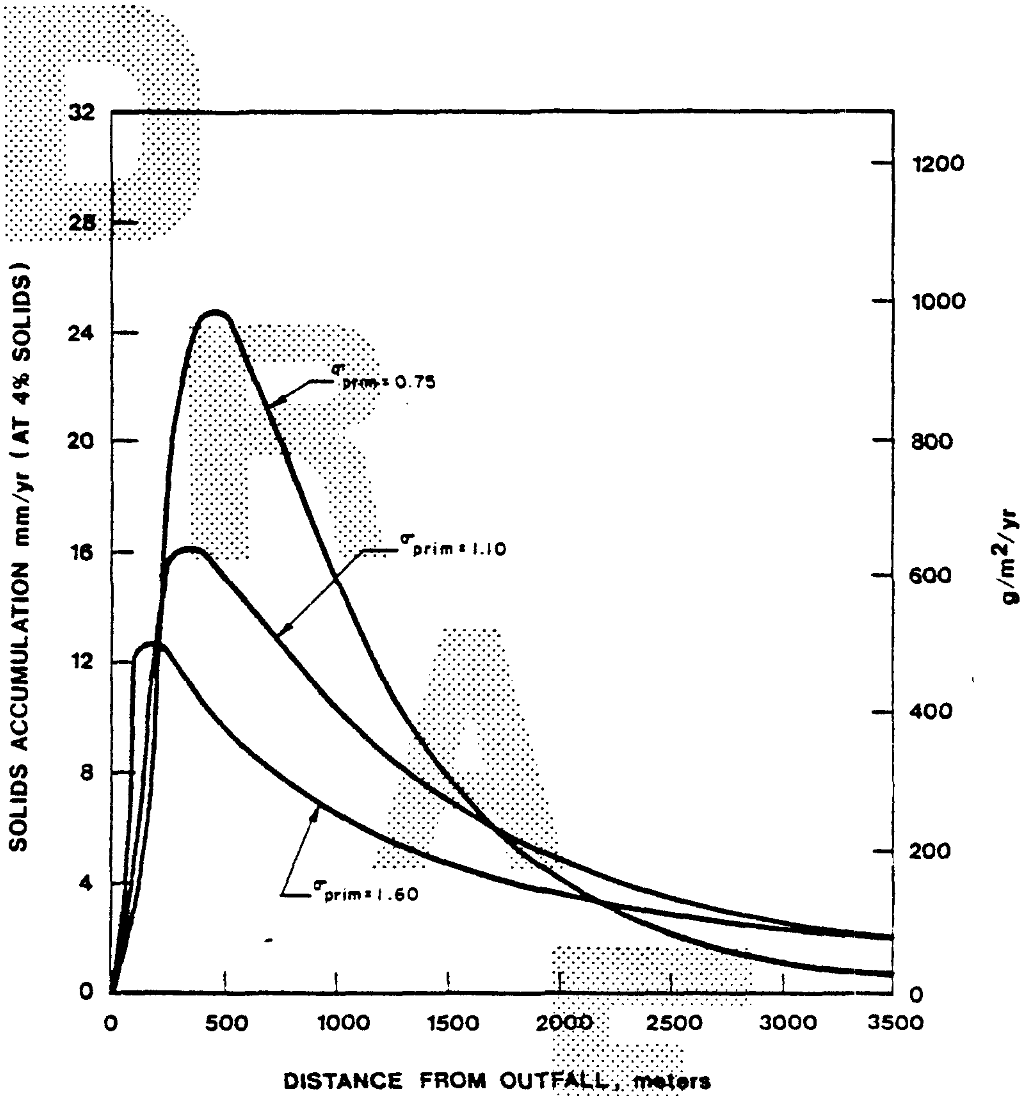
This means that the point of intersection of Curves (7), (8), and (9) could be moved horizontally to the right (see Figure 17), while at the same time keeping the w_{50} values constant. Altering the settling speed curves in this manner produces higher seabed accumulation rates since a higher fraction of the particles has greater settling speeds.

Third, the applicant predicts that the settling speed curves are considerably more flat than any of the historical curves [(1) through (6)]. In Figure 17, the vertical axis is a logarithmic scale (base 10), so that for every one unit change in the logarithm, the settling speeds change by a factor of 10.

Although, from a theoretical viewpoint, the settling speed curves of particles in primary effluent should be flatter than the settling speed curves for raw wastewater, the applicant's particular approach is questionable for the following reason. Curves (10), (11), and (12), which have been plotted for this review, represent treated effluent at three locations in California (Herring and Abati 1978). The applicant's predicted settling speed distributions are flatter than these curves. It should also be noted in Figure 17 that none of the six historical curves used by the applicant to represent raw wastewater are actually raw wastewater. Based on the nine historical curves, the applicant's predicted curves might be too flat (slopes too low). If the applicant had used the average slope of the historical curves, instead of estimating a slope based on an assumed relationship between the settling velocity distribution of the raw influent and primary effluent settling velocity distributions, the predicted deposition rates would be lower.

The applicant also generates three deposition profile curves which show deposition rates as a function of distance from the diffuser. The profiles are shown here as Figure 18. The curves are based on the three settling velocity distributions generated by the applicant which were shown in Figure 17. It is the lower curve (σ_{prim} = 1.5) from which the applicant chooses to develop the deposition pattern shown earlier in Figure 16, and not the "intermediate value" of σ_{prim} = 1.1. The maximum deposition rate corresponding to the latter settling velocity distribution is 650 $g/m^2/yr$. For the extreme case (σ_{prim} = 0.75) the predicted maximum deposition rate is 1,000 $g/m^2/yr$. This discussion illustrates that the settling velocity *distribution strongly influences predicted deposition patterns. Based on* historical settling velocity curves plotted in Figure 17 [Curves (10), (11), (12)] it appears that each of the applicant's choice of settling velocity distribution [Curves (7), (8), (9)] is conservative.

Figure 18 also shows the depth accumulation rate (in mm/yr) based on the mass deposition rate ($g/m^2/yr$) and 4-percent solids content. The



REFERENCE: FIGURE IX-2, NEW BEDFORD 301(h) APPLICATION, 1979

Figure 18. Applicant's calculated solids deposition rates, New Bedford, MA, treatment plant.

4-percent solids content is probably a low estimate for solids which settle on the ocean floor and begin to consolidate. Myers (1974) found that the solids content of sediments in the vicinity of the Whites Point outfall in southern California varied from about 15 percent at the seabed surface to 70 percent at depth. As the percent solids increase in a sediment deposit of constant weight, the depth of the deposit decreases. For example, a sediment deposit of 15-percent solids occupies a depth 25 percent as great as a 4-percent solids deposit. Hence, the deposition rates expressed as depth shown in Figure 18 are probably too high at the corresponding mass deposition rate.

The suspended solids mass emission rate used by the applicant in predicting seabed deposition is 19,000 kg/day (42,200 lbs/day). This mass emission rate is based on an effluent suspended solids concentration of 110 mg/l and a flow rate of 2.018 m^3/sec (46.06 MGD). According to the NPDES Standard Form A, the New Bedford treatment plant will achieve an effluent having an annual average suspended solids concentration of 50 mg/l by 1986. Historically, however, averages have been higher. Table 19 shows that the average effluent suspended solids level was 127 mg/l for 1979-1980.

The flow rate used by the applicant is a 2-h maximum flow rate. It is more correct to use a longer term average flow rate of 1.1 m^3/sec (25 MGD) rather than this more extreme flow rate. Once the improvements to the primary plant are completed (circa 1986) the average suspended solids mass emission rate should average 4,700 kg/day (10,400 lbs/day) if the effluent suspended solids is 50 mg/l. Prior to that time the average mass emission rate will be closer to 12,000 kg/day (26,500 lb/day). Using these two mass emission rates the deposition contours shown in Figure 16 can be adjusted as follows (assuming all other conditions remain the same).

Mass Emission Rate	Deposition Rates ($g/m^2/yr$) in Figure 16		
19,000 (applicant's value)	500	250	125
12,000 (historical average)	320	160	80
4,700 (post 1986, assuming SS_e = 50 mg/l)	120	60	30

The large reductions in the mass emission rates significantly decrease the predicted deposition rates.

Figure 16, shown earlier, is based on the assumption that 100 percent of the discharged solids will settle onto the seabed and that the solids will remain there indefinitely. Each of these assumptions tends to overestimate the net deposition rates.

The applicant predicts that the lower limit of the particle settling velocity should not differ much from the volume-averaged clarifier overflow rate, and thus very little accumulation of solids will actually occur. The applicant's argument is based on the following expression:

$$\frac{C}{C_a} = \left(\frac{Y-z}{Y-a} \cdot \frac{a}{z}\right)^{w/(ku_*)}$$

where:

Y = total depth of water

C = suspended sediment concentration at z

z = distance above bottom

C_a = suspended sediment concentration at a distance a above the bottom

w = particle fall velocity

k = von Karman's constant

u_* = shear velocity.

The applicant chooses a value of 0.24 for $w/(ku_*)$ to define the effective lower limit of settling.

This expression, as discussed in numerous text books on sediment transport in rivers (e.g., Graf 1971), has a specific and limited application. It is valid only for the steady state transport of suspended solids in a river where there are no gradients of sediment concentration in the direction of flow or horizontally perpendicular to the flow direction. The suspended solids distribution in the vertical is assumed to have attained an equilibrium level and does not change with distance. It is probable that, to some degree, all of these assumptions are violated in the case of an ocean discharge. Consequently, the prediction based on this expression is of limited validity. Even so, it is probable that some fraction of the discharged solids will either not settle, or settle so slowly as to contribute minimally to deposition rates.

The applicant also briefly analyzes the propensity of the settled solids to be resuspended. Based on the work of Hendricks (1976) the applicant chooses 20 cm/sec (0.7 ft/sec) as the minimum velocity required to produce resuspension. This is probably a high estimate since Hendricks (1976) also found that velocities as low as about 6 cm/sec (0.2 ft/sec) would, at some locations, produce resuspension. The applicant then states that "solids that do settle may well be subject to resuspension by the tidal currents, whose values in the outer harbor often exceed 20 cm/sec."

The applicant's statement can be augmented as follows. Current meter data were collected at several stations near the existing and proposed outfalls in the summer of 1979. Station C' (see Figure 14) is closest to the proposed outfall, although the depth of water is only 12.8 m (42 ft). Current data were collected at depths of 5 m (16 ft) and 9 m (39 ft) over a 16-day period. Based on the data contained in Appendix II of the application a cumulative density distribution of speeds can be generated. The results can be used to estimate whether or not resuspension is likely to occur at the proposed outfall, even though the data are limited and the water depth is less by 3.9 m (13 ft). Figure 19 shows the resulting distribution. Based on this particular distribution, speeds exceed 20 cm/sec (0.7 ft/sec) for about 14 percent of the observations, and were observed to be as high as 38 cm/sec (1.2 ft/sec). Currents were in the range of 6 to 20 cm/sec (0.2 to 0.7 ft/sec) for 60 percent of the observations, and were below 6 cm/sec (0.2 ft/sec) 26 percent of the time. Based on the applicant's criterion of resuspension occurring when current speeds exceed 20 cm/sec (0.7 ft/sec), it does not appear that resuspension is frequent. However, if resuspension is possible for speeds exceeding 6 cm/sec (0.2 ft/sec), then resuspension could occur up to 75 percent of the time.

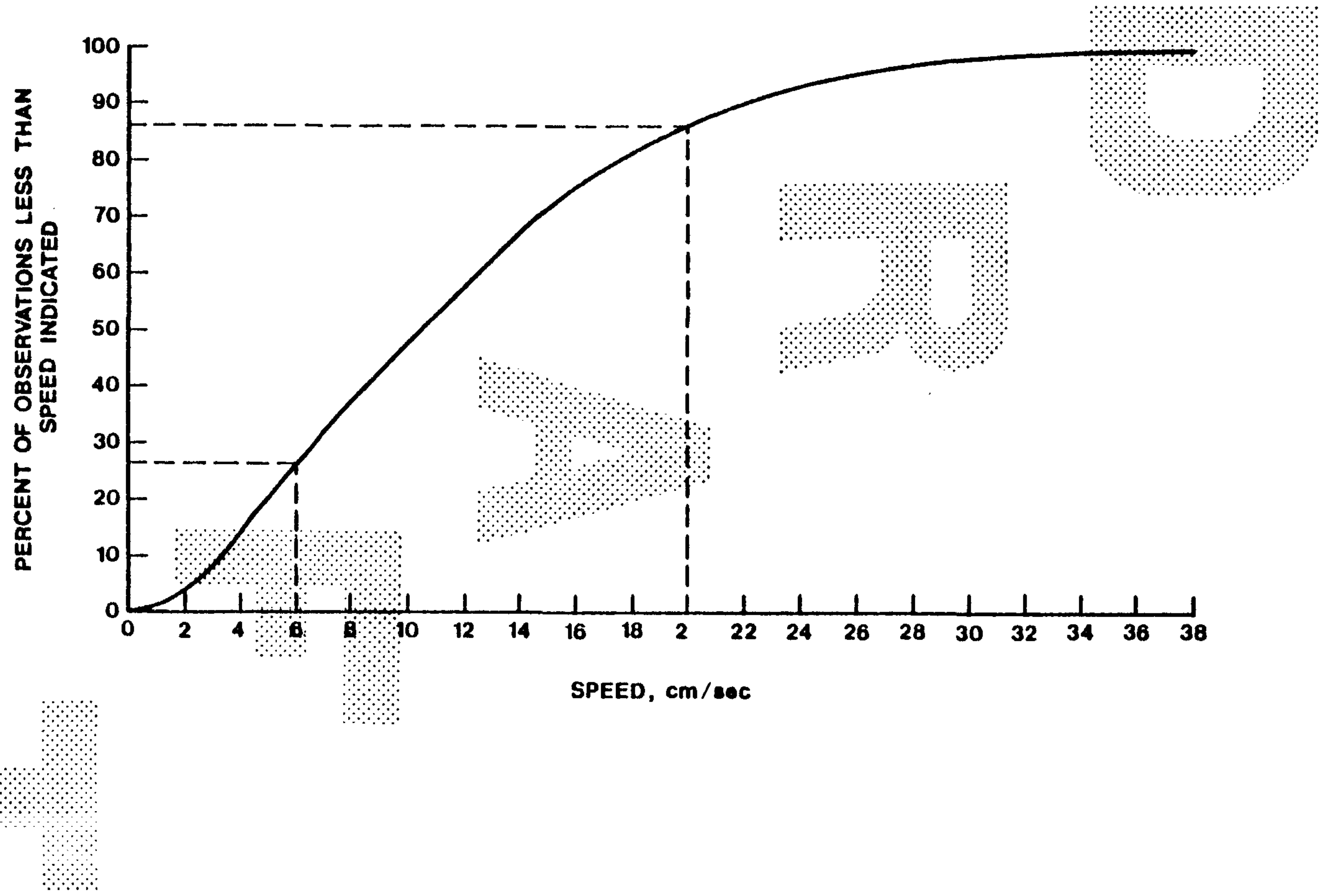


Figure 19. Cumulative frequency distribution of current speed at a depth of 9 m at Station C', New Bedford, MA.

Section 5. Public Water Supply Impact Assessment

The applicant states that there are no existing or planned desalinization plants producing water for public water supplies in the area. This was confirmed with the Massachusetts Division of Pollution Control[a]. The Commonwealth of Massachusetts does not have specific standards for saltwater used as a source for public water supplies.

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[a] Personal communication (phone) on February 9, 1981, by Karen Summers with Jerry McCall of the Massachusetts Division of Pollution Control.

Section 6. Biological Conditions Summary

The Biological Conditions Summary (BCS) for the New Bedford application is supplied as Appendix XI. The applicant presents data in the BCS for the following biotic groups: phytoplankton, zooplankton, benthic infauna, intertidal macrofauna/algae, demersal fishes/megafaunal invertebrates, and shellfish. Studies of bioaccumulation of toxic substances are discussed by the applicant in Appendix XVII.

Phytoplankton--

The applicant bases its evaluation of potential impacts on phytoplankton due to the existing effluent discharge and its prediction of possible impacts due to the proposed discharge on the results of a limited sampling program conducted in the vicinity of the outfall and reference areas during August, 1979.

Study Design--Phytoplankton samples were collected at six stations: one within the ZID, one immediately beyond the ZID, one at the proposed outfall, one in Nasketucket Bay to be used as a control for the existing outfall, and two other stations in the general area of the proposed outfall. There is some uncertainty concerning the exact locations of the within-ZID and near-ZID stations (see Sampling Stations and Reference Area Evaluation, below). Collection of phytoplankton at these two stations may not be adequate for a definitive evaluation of potential impacts of the effluent discharge on phytoplankton, since such effects may not be manifested in the immediate vicinity of the outfall. Phytoplankton are carried about by movements of the water and there may be a lag time in the response of phytoplankton to effluent inputs. Consequently, phytoplankton should be sampled at varying distances from the outfall, preferably in the direction of current flow. The next closest station to the outfall may have been too far away [2.7 km (1.65 mi)] to detect an effluent-related effect. In addition, it is not indicated whether this next closest station was in the direction of current flow from the outfall at the time of sampling.

During the sampling program, phytoplankton were apparently collected only once at each station. All sampling was completed between August 15-17, 1979. Collection of samples over only a 3-day period does not permit examination of seasonal variations in the phytoplankton community, which are an integral factor in the definition of a balanced, indigenous population. Samples were collected at the surface and at mid-depth at each station, but replicate samples at each depth were apparently not collected. The lack of replicate samples precludes estimation of within-station variability, and hence extremely limits statistical analysis of the data.

The applicant conducted only a taxonomic analysis of the phytoplankton samples. Taxonomic characterization of the phytoplankton permits evaluation of discharge-related alterations in the community composition, but does not allow evaluation of changes in the overall level of primary production, which may be affected by effluent inputs. Measurement of primary productivity and/or community biomass (as chlorophyll a) would have been a valuable addition to this sampling program.

Sampling Stations and Reference Area Evaluation--The locations of the six phytoplankton stations are shown in Figures XI-1 and XI-2 of the application (reproduced here as Figures 20 and 21). The applicant describes Station P1 as being "within the ZID" and Station P2 as being "immediately beyond the ZID." The location of the outfall is not shown in Figure XI-1 of the application, but was added in Figure 20 of this evaluation. Coordinates of the phytoplankton stations are not given, although they presumably coincide with those of the similarly-numbered benthic sampling stations in Table XI-1 of the application. If the coordinates listed are correct (see further discussion under Benthos subsection below), it would appear that both Stations P1 and P2 are beyond the ZID, and that Station P1 [167 m (548 ft) from the outfall terminus] is actually farther away from the outfall than is Station P2 [76 m (249 ft)]. This apparent discrepancy cannot be resolved with the information available in the application. Both Stations P1 and P2 may be considered near-ZID stations for evaluation of possible effects on phytoplankton.

Reference Station P17 is located in approximately 6.1 m (20 ft) of water in Nasketucket Bay (Figure 21). This is somewhat shallower than the water depth at the site of the existing outfall [8.8 m (29 ft)]. Nevertheless, this station appears to be sufficiently removed from other anthropogenic pollutant sources to serve as an adequate control. It is not known what tidal stage prevailed at the time of sampling. Depending upon the tidal stage, this station may have been more influenced by inshore waters or offshore waters than corresponding stations in the vicinity of the existing outfall.

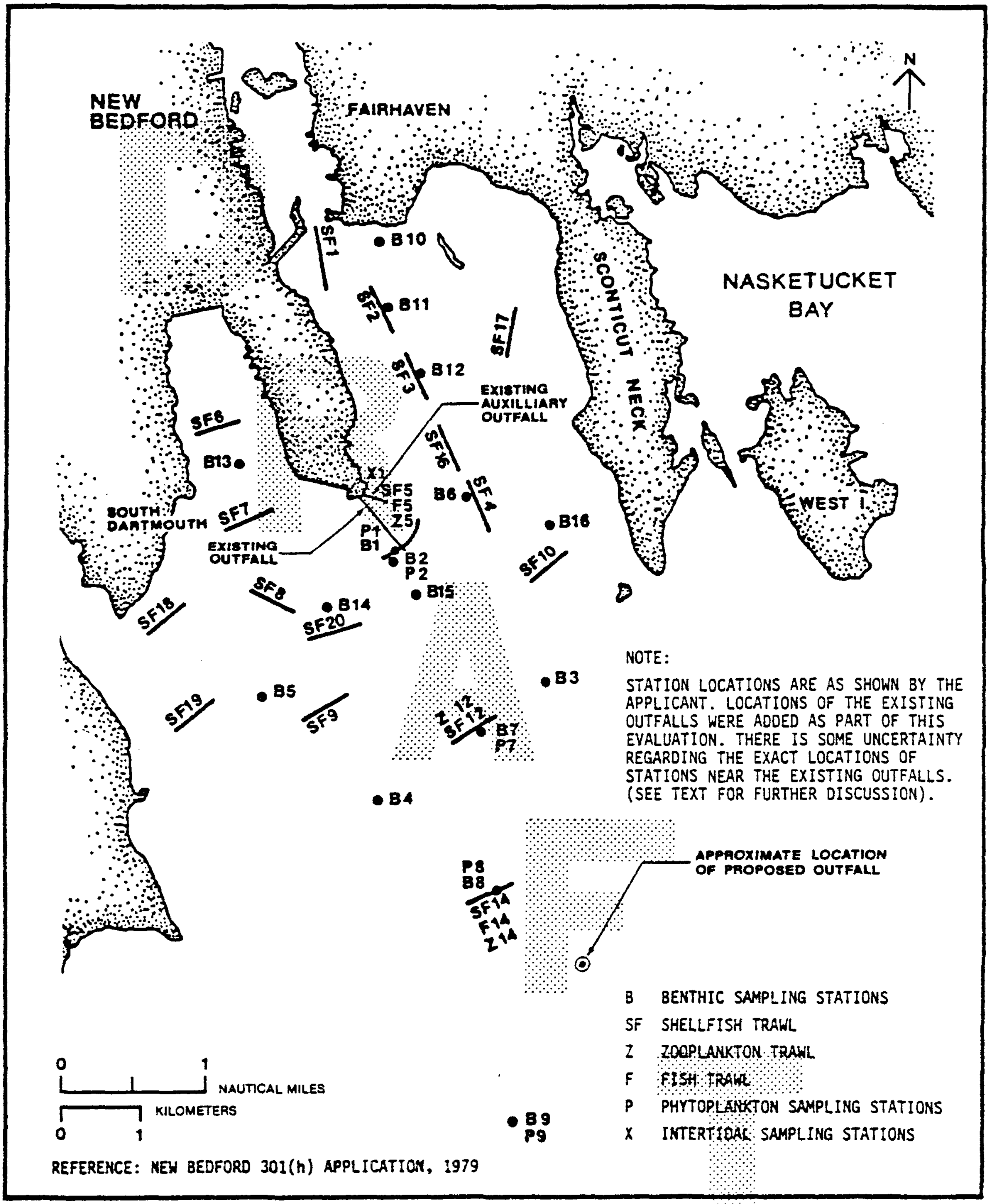

Figure 20. Location of biological sampling stations, New Bedford, MA.

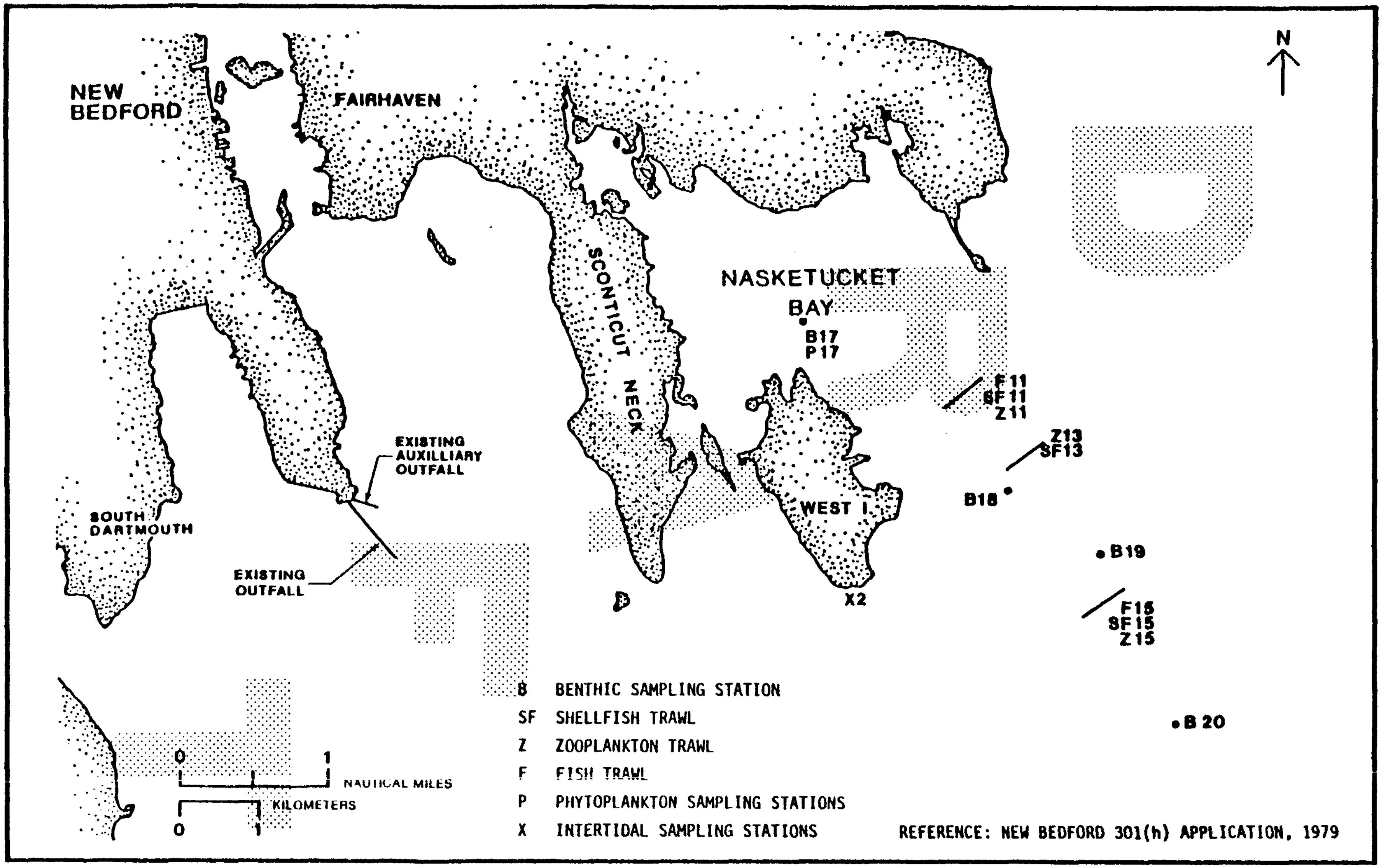

Figure 21. Location of control stations for biological sampling, New Bedford, MA.

Phytoplankton Station P7 (Figure 20) is located approximately 2.7 km (1.65 mi) offshore from the existing outfall, and therefore might be considered a beyond-ZID station. As noted above, however, it is not indicated whether this station was in the direction of current flow from the outfall at the time of sampling. This station may have been too far away from the outfall to detect an effluent-related effect on phytoplankton.

Phytoplankton Station P8 is located still farther offshore (Figure 20), and although it is described by the applicant as being "at the proposed outfall," it was apparently positioned approximately 1.2 km (0.8 mi) inshore of the proposed diffuser. While such a displacement is of little consequence for the sampling of planktonic organisms which are subject to advection, it would have been preferable to sample in the immediate vicinity of the site of the proposed discharge.

Phytoplankton Station P9 is located still farther offshore (Figure 20), and would probably reflect conditions unlike those at the more inshore stations. The purpose of sampling at this station is not reported.

<u>Sampling Procedures</u>--Phytoplankton samples were collected with a 2-l water bottle at the surface and at mid-depth. The samples were preserved with buffered formalin and later analyzed in the laboratory using the Utermohl technique (Sournia 1978). These are acceptable procedures except that it should be noted that formalin is not appropriate for the preservation of all phytoplankton. In particular, flagellated forms might

be better preserved in Lugol's solution (Stofan and Grant 1978). It would also have been preferable to collect replicate samples from each depth at each station.

Taxonomic Procedures--Taxonomic identifications were made by using a phase contrast, inverted microscope at 1250X. The applicant lists a number of taxonomic references utilized for the identification of phytoplankton. Counting of individual taxa was conducted until approximately 100 units (a unit was defined as a cell, filament, colony, or frustule) of the most numerous taxon had been found. Unfortunately, the applicant simply reports the list of taxa identified (only a few of which were identified to species) and does not provide information on their individual abundances. The only quantitative data provided in the application are grouped by major taxa (e.g., Chlorophyta, Bacillariophyceae, etc.), so it is not possible to compare the relative abundances (or even the presence or absence) of individual taxa among stations. Failure to identify the majority of the phytoplankton beyond the generic level is also a serious omission. It is impossible to adequately define a balanced, indigenous population without accurate identifications to species.

Statistical Procedures--The density of phytoplankton cells (both for individual taxa and for the entire community) in the two phytoplankton samples (one surface and one mid-depth) from each station were apparently averaged to give a single value of each parameter for each station. The mean densities for individual taxa are not reported, but again, the cell densities and percent contribution to the total phytoplankton community in each of a number of broad taxonomic groups are tabulated for each of the six stations (Table XI-16 of the application). The raw data are not reported, however. The applicant utilizes several statistical procedures for comparison of the phytoplankton at the six stations. In Table XI-17 of the application (reproduced here as Table 24) values of the Shannon-Wiener diversity are reported for each station, although it is not clear how they were calculated (using individual taxa or the broader taxonomic groupings; using the pooled phytoplankton samples from each station or the individual samples). In addition, Jaccard's similarity coefficients were computed for comparison of the phytoplankton taxa between each pair of the six stations. This coefficient is simply the quotient of the number of taxa occurring in common between two samples divided by the total number of taxa occurring in the two samples. It therefore represents only the percent of the taxa found in common between two samples. It does not taken into account differences in the abundances of individual taxa between the two samples. Finally, chi-square values were computed for comparison of phytoplankton unit densities among the major groups (Table 24). Once again, it is not clear whether these chi-square values were computed using the pooled phytoplankton samples from each station or the individual samples. Also reported in Table 24 (but not statistically compared, due to the lack of replicate samples) are the total densities of phytoplankton cells at each station and the numbers of phytoplankton taxa observed at each station.

<u>BIP Comparison</u>--For a proposed improved discharge (involving relocation) into unstressed ocean waters, the applicant should compare communities at the ZID boundary with the balanced, indigenous population at

TABLE 24. TOTAL PHYTOPLANKTON DENSITIES, NUMBERS OF TAXA, SHANNON-WIENER DIVERSITIES AND CHI-SQUARE RESULTS FOR PHYTOPLANKTON SAMPLES COLLECTED ON AUGUST 15-17, 1979

Station	Total Density[a] (units/ml)	Taxa[b]	Shannon-Wiener Diversity	Chi-square[c]
P1	8,545	22	2.03	(1 vs. 2) 2422[d]
P2	5,156	26	2.22	(2 vs. 7) 1204[d]
P7	3,263	27	2.37	(7 vs. 17) 20272[d]
P8	1,732	22	2.14	(1 vs. 8) 5567[d]
P9	1,946	21	1.93	(2 vs. 9) 2044[d]
P17	5,679	22	1.66	(1 vs. 17) 6000[d]

[a] Although not explicitly stated, these total densities are apparently station means calculated from the surface and mid-depth samples.

[b] The number of taxa/sample does not include unidentified forms.

[c] It is not clear from the text what hypothesis was being tested or how these values were calculated.

[d] $P < 0.001$.

Source: Table XI-17 of the application.

an unstressed control location, and the applicant should describe the present biological conditions at the proposed outfall site.

Phytoplankton sampling conducted in support of the application is insufficient for making the required BIP comparison for the following reasons:

1. Collection of phytoplankton at only two stations in the vicinity of the outfall may not be adequate for a definitive evaluation of potential impacts of the effluent discharge on phytoplankton, since such effects may not be manifested in the immediate vicinity of the outfall.

2. Characterization of a BIP of phytoplankton for this area was inadequate due to lack of information on seasonal variability, omission of measurements of primary productivity and/or community biomass, and failure to identify the majority of phytoplankton to species.

3. The lack of replicate samples at each station precluded an evaluation of the significance of observed differences between stations in cell densities and/or numbers of taxa.

The applicant indicates that the small (5-10 um) centric diatom, *Cyclotella michiganiana*, was "a dominant density component of the phytoplankton at all stations." Other abundant taxa were small cryptophyte and chrysophyte phytoflagellates at Stations P1, P2, P7, and P8, cryptophyte phytoflagellates at Station P9, and the diatom Skeletonema costatum, at Station P17. Hulburt (1963) attributed the dominance of shallow, nearshore coastal regions in New England by small diatoms and phytoflagellates to the higher settling rates of larger diatoms that dominate offshore regions. In the absence of abundance estimates for individual taxa, it is not possible to compare quantitatively the applicant's phytoplankton data with those of other investigators to examine possible alterations in dominance relationships.

Jaccard's similarity coefficient, used to assess qualitative differences in the phytoplankton populations at the various stations, ranged between 0.41-0.66 for the 15 station-station comparisons (Table 25). This implies that individual stations only had 41-66 percent of their phytoplankton taxa in common with other stations. The applicant asserts that the outermost stations (P7, P8, and P9) had "the greatest numbers of common phytoplankton taxa." The applicant further claims that:

> "There were no major differences among Stations P1 and P2 (in and immediately beyond the ZID), Stations P7, P8 and P9, and Station P17 (reference) indicate by Jaccard's coefficients."

The Jaccard coefficients for comparisons of Stations 1 and 2 with the other stations ranged from 0.41 to 0.57 (Table 25); it is not known how small this coefficient would have to be for the applicant to consider it a "major qualitative difference." The fact that the phytoplankton assemblages were so

TABLE 25. JACCARDS'S COEFFICIENT OF COMMUNITY[a] FOR PHYTOPLANKTON SAMPLES COLLECTED AUGUST 15-17, 1979

Station	P1	P2	P7	P8	P9	P17
P1		0.50	0.53	0.42	0.43	0.52
P2			0.51	0.41	0.57	0.45
P7				0.58	0.66	0.44
P8					0.65	0.57
P9						0.48

[a] The Jaccard's coefficient of community (CC) is calculated as:

$$CC = \frac{c}{a + b - c}$$

where:

a = number of species in sample a

b = number of species in sample b

c = number of species in both a and b

markedly different between stations, even when the stations were close together (Station P1 and P2 had a Jaccard coefficient of only 0.50), suggests that the phytoplankton community at each station may not have been adequately characterized. Collection of more samples at each station or counting a larger fraction of each sample might have resulted in more taxa being found at each station.

The applicant reports that the selected chi-square analyses (Table 24) demonstrated that there were significant ($P < 0.001$) differences among the stations in the "unit abundance of major phytoplankton groups." It is not clear how these chi-square values were calculated or what these "major phytoplankton groups" were. Attempts to calculate (as part of this evaluation) chi-square values for the stated comparisons using the unit densities reported in Table XI-16 of the application were unsuccessful at reproducing the chi-square values reported by the applicant (Table 24). If densities within individual taxa were used rather than densities within the major groups, the highly significant chi-square values may only reflect the fact that the stations had so few taxa in common (as indicated by the Jaccard similarity coefficients). The applicant does not give any interpretation for the fact that all stations tested had significantly different phytoplankton assemblages.

With regard to cell densities, the applicant asserts that:

> "There were no large density differences among the major phytoplankton groups at any of the stations that could not be

explained as natural variability in the phytoplankton communities."

Examination of the applicant's Table XI-16 would seem to corroborate this assertion, although it should be noted that replicate samples and rigorous statistical analyses would be required to estimate the statistical significance of any observed differences in the abundances of major phytoplankton groups. The possibility also exists that large differences occurred between stations in the abundances of individual taxa. Since these abundances are not reported, this possibility cannot be explored.

The applicant notes that members of the Euglenophyta and Cyanophyta (two groups which sometimes attain high densities in eutrophic systems) were present near the existing outfall (Stations P1 and P2) and at Station P7. Members of the Cyanophyta were also present at Stations P8 and P9, however, and both groups were in low abundance at all stations where they were present. Since they were not present in high abundance near the outfall, severe eutrophication is not suggested.

The total phytoplankton density ranged from 8,545 cells/ml at Station P1 (nominally within the ZID of the existing outfall) to 1,832 cells/ml at Station P8 near the proposed outfall (Table 24). While higher densities at the existing outfall are suggestive of sewage enhancement of phytoplankton growth, they may only represent a typical onshore-offshore gradient in phytoplankton abundance. In support of this interpretation is the fact that the second highest phytoplankton abundance was at the control station, P17.

The total phytoplankton density reported for the outfall station is similar to the density of phytoplankton cells in Lower Narragansett Bay in late summer (Smayda 1958), suggesting that this is not an abnormally high density. Once again, replicate samples and rigorous statistical analyses would be required to estimate the statistical significance of any observed differences in total phytoplankton abundance. It would also be helpful to have more stations in closer proximity to the existing outfall.

In summary, the phytoplankton data collected in 1979 revealed dramatic differences in community composition and minor differences in overall abundance, both between two stations in the immediate vicinity of the existing outfall ZID and between these stations and four other stations, including a reference station in Nasketucket Bay and a station near the site of the proposed outfall. Certainly, more extensive sampling would be required to determine whether these observed trends are statistically significant and whether they occur at other times throughout the year. With the data currently available, it cannot be determined whether these differences are related to the discharge of sewage effluent.

Occurrence of Pollution-Resistant and Nuisance Species--Among the marine phytoplankton, species commonly believed to be nuisance species are generally dinoflagellate species associated with red tides. The applicant notes that species of *Gymnodinium* and other dinoflagellate genera were found at all stations, but that they were always present in low densities and no toxic species were identified. In New England, red tides which have caused paralytic shellfish poisoning (PSP) are caused by *Gonyaulax tamarensis*, but the applicant does not list Gonyaulax among the dinoflagellate genera identified during the phytoplankton study. Its absence from the area during the limited duration of the phytoplankton study does not mean that it never occurs in the area, however. Red tides have never been reported from the New Bedford area, and the closest they have occureed to New Bedford is in the Falmouth area, approximately 24 km (15 mi) from New Bedford on the opposite side of Buzzards Bay[a]. The extent to which the discharge of sewage effluents in the New Bedford area will enhance the growth of red-tide organisms in the future is unknown.

Zooplankton--

The applicant bases its evaluation of potential impacts on zooplankton due to the existing effluent discharge and its predictions of possible impacts due to the proposed discharge on the results of a limited sampling program conducted during 1979.

Study Design--Zooplankton sampling was conducted during 14-17 August, 1979, at six locations: one at the site of the existing outfall, one near the site of the proposed outfall, one between these two locations, and three

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[a] Personal communication (phone) on September 14, 1981, by Dr. Lawrence E. McCrone, with Mr. Richard Packard, Mass. Dept. Environmental Quality Engineering, New Bedford, MA.

control locations in Nasketucket Bay. Effects of an effluent discharge on zooplankton may not be manifested in the immediate vicinity of the outfall since zooplankton are carried about by movements of the water. While the intermediate location offshore of Clarks Point could serve as a beyond-ZID location for the detection of possible outfall-related effects on zooplankton, it is not known whether this site was upcurrent or downcurrent from the outfall at the time of sampling. Consequently, zooplankton at this site may or may not have experienced effects from the effluent discharge.

Apparently, sampling consisted of the collection of only a single sample at each location. This does not permit estimation of within-station variability and hence precludes statistical analysis of the data. Collection of samples over only a few days also does not permit examination of seasonal variations in the zooplankton community, which is an integral factor in the definition of a balanced, indigenous population.

Sampling Stations and Reference Area Evaluation--The six locations where zooplankton sampling was conducted are shown in Figure 20. Since the sampling was conducted by towing a net obliquely while the vessel was underway (see Sampling Procedures below), the locations sampled are represented by transects over horizontal distances of approximately 610 m (2,000 ft), rather than by fixed stations. Transect Z5 is in the immediate vicinity of the ZID of the existing outfall, but given the scale of the applicant's map, it is impossible to determine whether this transect enters the ZID. Hence, transect Z5 should be considered a near-ZID location. Transect Z12 is located approximately 2,438 m (8,000 ft) offshore of transect Z5, and therefore might be considered a beyond-ZID station. As noted above, however, it is not known whether this site was upcurrent or downcurrent from the outall at the time of sampling, which would determine whether the zooplankton at this site may have been influenced by the effluent discharge. Transect Z14 was still farther offshore, and although it was described by the applicant as "near the proposed improved outfall," it was apparently located approximately 1,219 m (4,000 ft) inshore of the proposed diffuser. While such a displacement is of little consequence for the sampling of planktonic organisms which are subject to advection, it would have been preferable to sample in the immediate vicinity of the site of the proposed discharge.

The remaining three transects are all located in Nasketucket Bay (Figure 20). Each of the three is positioned with regard to depth and hydrography in order to serve as controls for the three previously mentioned stations. All three transects in Nasketucket Bay appear to be sufficiently removed from other anthropogenic pollutant sources to serve as adequate controls. Once again, it is not known what tidal stage prevailed at the time of sampling. Depending upon the tidal stage, these locations may have been more influenced by inshore waters or offshore waters than the corresponding locations in the vicinity of the existing and proposed outfalls.

Sampling Procedures--Zooplankton were collected by towing a net from just above the bottom to the surface while the vessel was underway at an approximate speed of 1 m/sec (2 knots). The net used had a 0.5-m (1.64-ft) mouth diameter and a mesh of 202 um. While a 0.5-m (1.64-ft) mouth diameter is slightly smaller than that generally recommended for coastal zooplankton collections [0.6 m (1.97 ft), cf. Jacobs and Grant 1978], a mesh of 202 um is appropriate. Oblique tows at a ship's speed of 1.0 m/sec (2 knots) are an acceptable sampling method. The volume of water passing through the net was calculated through the use of a flowmeter suspended in the mouth of the net. Replicate samples were apparently not collected at any of the stations. Zooplankton samples were preserved with a 5 percent buffered formalin solution. Identifications were made using a binocular compound microscope.

Taxonomic Procedures--Taxonomic procedures utilized were not specified (although a list of general taxonomic references was provided), and it is not known what qualifications the person(s) analyzing the samples possessed. The applicant reports that 48 species or taxa were found in the six samples. The size of the subsamples counted is not reported.

Statistical Procedures--The only quantitative analyses of the zooplankton data were the calculation of the Shannon-Wiener diversity index for each sample and the comparison of the individual samples with one another through the use of Jaccard's coefficient of community (cf. Clifford and Stephenson 1975; Boesch 1977) and weighted clustering techniques based on the Czekanowski index of affinity (cf. Boesch 1977).

The applicant reports only the range of values for the Shannon-Wiener diversity index: 2.8028 (Sample Z11) to 3.3682 (Sample Z14). The other values, calculated as part of this evaluation, were 2.89, 3.03, 3.25, and 3.06 for samples Z5, Z12, Z13, and Z15, respectively. The applicant concludes that "Diversity values within this range indicate a fairly diverse community" and that the "spread of values was not great enough to indicate an appreciable difference among the stations."

The calculated Jaccard coefficients are not reported by the applicant; the only conclusion is that they "yielded a relatively high affinity among the stations." This coefficient is simply the quotient of the number of taxa occurring in common between two samples divided by the total number of taxa occurring in the two samples. It therefore represents only the percent of the taxa found in common between two samples. It does not take into account differences in the abundances of individual taxa between the two samples. The applicant further indicates that "The resulting dendrogram (Figure XI-8) [of the application] did not yield any readily explainable [sic] grouping of stations," suggesting that the Jaccard coefficient was used as the basis for the clustering algorithm. Attempts to confirm this method of calculation were made as part of this evaluation, however, and it was not possible to recreate the applicant's dendrogram.

After discussing the Jaccard coefficient, the applicant indicates that "Weighted clustering techniques based on the Czekanowski Index of affinity and the pair grouping methods" used for drawing the dendrogram "produced a consistant [sic] pattern for the station." It seems likely, therefore, that the dendrogram (Figure XI-8 of the application) mentioned in conjunction with the discussion of the Jaccard coefficient was in fact based on the

Czekanowski index and not on the Jaccard coefficient. Too little information is supplied by the applicant to confirm this supposition, however. For the analysis of the demersal fish and megafaunal invertebrate data, the applicant utilized "A standardized Bray-Curtis similarity coefficient (Boesch 1977) and the unweighted pair-group method using arithmetic averages" for the construction of dendrograms. The applicant altered the data somewhat by performing a log(x+1) transformation "to equalize the contribution of rare and abundant species" and by eliminating "those species which occurred only rarely." If similar methods were used with the zooplankton data, this could explain the inability to recreate the applicant's dendrogram as part of this evaluation.

The lack of replicate samples from each station precludes statistical analysis of differences in abundance between stations, either for individual taxa or for the zooplankton community as a whole.

BIP Comparisons--For a proposed improved discharge (involving relocation) into unstressed ocean waters, the applicant should compare communities at the ZID boundary with the balanced, indigenous population at an unstressed control location, and the applicant should describe the present biological conditions at the proposed outfall site.

Zooplankton sampling conducted by the applicant is insufficient for making the required BIP comparisons for the following reasons:

1. There has been no attempt to accurately define a BIP of zooplankton characteristic of this biogeographic zone. Particularly lacking are estimates of both within-station and seasonal variability.

2. The lack of replicate samples precludes statistical analysis of differences in abundance between stations, either for individual taxa or for the zooplankton community as a whole.

3. Failure to note the tidal stage at the time of sampling opens the question of whether or not the beyond ZID sample could be expected to show effects of the effluent discharge. This omission also renders the comparison of the outfall stations with the control stations in Nasketucket Bay of dubious significance, since, depending upon the tidal stage, the control stations may have been more influenced by inshore waters or offshore waters than the corresponding stations in the vicinity of the existing and proposed outfalls.

Due to the extremely limited zooplankton sampling program (one sample at each of six stations), the applicant's conclusions should be regarded as very tenuous. In the absence of information on within-station and/or seasonal variability, statements that "Diversity values within this range indicated a fairly diverse community" and that the "spread of values was not great enough to indicate an appreciable difference among the stations" cannot be taken as conclusive evidence that the existing effluent discharge has not adversely affected the zooplankton communities.

Uncertainty over the method used for constructing the similarity dendrogram renders it of questionable utility in the examination of possible outfall-related effects. It is interesting to note, however, that the three Nasketucket Bay control samples clustered apart from the other samples, and that the sample collected at the existing outfall (Z5) only joined the cluster formed from the other five stations at a low (< 0.4) similarity (see Figure XI-8 of the application). The applicant attributed the latter effect to the large catch of larval barnacles (<u>Balanus</u> spp.) and larval gastropods at Station Z5. While it is doubtful that an increased abundance of these forms would be related to the effluent discharge, it does open the question of the comparability of the outfall and "control" stations, where the abundance of these forms was considerably lower.

The applicant states that:

> "Total number of individuals per/m^3 [<u>sic</u>] indicates a definite carrying capacity for both the Nasketucket Bay and New Bedford Outer Harbor area with the Harbor having the greater capacity."

While the total zooplankton abundance was in each case higher at the harbor stations than at the corresponding control stations in Nasketucket Bay, it does not seem justified to conclude that the populations in either area have reached the carrying capacity of the environment, or that any of the observed differences are significant. Sampling variability alone could easily account for the observed range of total zooplankton abundances (4,372-7,819/m^3).

The applicant reports that copepods as a group dominated the zooplankton, with "21 taxa comprising 64% of all individuals." Actually, only 20 categories of copepods are listed in the applicant's Table XI-18, and a number of species are subdivided by developmental stage. Only nine copepod species were identified, of which Acartia tonsa and Paracalanus crassirostris were most abundant, comprising 31 percent and 23 percent of the total zooplankton, respectively. Decapod larvae were also abundant, with "nine taxa comprising 23% of the total zooplankton." Only three decapod species were identified however, of which Carcinus maenus was most abundant, comprising 10 percent of the total zooplankton. No other major group comprised more than 8 percent of the total zooplankton.

The applicant compared the holoplankton data from this study with data on copepod abundances in Buzzards Bay (Anraku 1964), and concluded that there were "no appreciable differences in the dominance between the copepods." This conclusion appears justified, since Paracalanus crassirostris and Acartia tonsa were also the dominant copepods in Buzzards Bay on August 17, 1960. The applicant attributed the higher density of copepods in Anraku's (1964) study to the smaller mesh nets used, which is entirely plausible.

The applicant also compared its holoplankton data with those of Jeffries (1962, 1964) from studies "located from Buzzards Bay to York River, Virginia." Actually, Jeffries studies were in Narragansett Bay (Rhode Island), Raritan Bay (New Jersey), and York River (Virginia). Only data from Narragansett Bay would be expected to be strictly comparable with those from New Bedford Harbor. These data would suggest, as the applicant notes, that the zooplankton samples collected in the New Bedford Harbor "indicate a typical coastal marine environment." Although not mentioned by the applicant, it is interesting to note that Jeffries (1964) reported increased numbers of lamellibranch veligers and _Balanus_ nauplii following reduction in pollutant levels in Raritan Bay. If true, this might suggest that the zooplankton in the vicinity of the existing New Bedford outfall is not currently stressed by pollution, since a high abundance of _Balanus_ spp. was found there.

The applicant concludes by stating "No effects which could be attributed solely to the outfall were observed in the zooplankton of the study area." While this is apparently true, certainly a more comprehensive sampling program would be necessary to state definitively that the existing discharge has not adversely affected the zooplankton communities.

Benthic Infauna--

Preface--The applicant summarizes the results of four studies of benthic infauna in Buzzards Bay, New Bedford Harbor, and Nasketucket Bay. Two of these studies, which were performed during May, 1979, and August, 1979, examined the influence of the existing New Bedford sewage discharge on infaunal communities. The May, 1979, study was a preliminary survey, whereas the August, 1979, study involved a more intensive sampling effort and more detailed data analyses. Most of the applicant's discussion of macrofaunal benthos is devoted to the August, 1979, survey. Although the applicant refers to a report (Camp, Dresser, and McKee 1979 as cited by applicant) containing information on the May, 1979, survey, this document was unavailable during preparation of this review. Accordingly, this evaluation will focus on the August, 1979, survey. The applicant also reviews two earlier studies by Sanders (1958) and Kelly (1978).

Study Design--Some aspects of general study design for the benthic infaunal surveys are presented in Table 26. Each survey was conducted as a single sampling series over a limited time period. Although Sanders (1958) sampled numerous stations throughout Buzzards Bay, the applicant presents his data from a single station which was regarded as "...within the present study area." Both Sanders (1958) and Kelly (1978) measured parameters other than those listed in Table 26; only those variables discussed by the applicant are included in Table 26. Grab samples of sediment and associated organisms were taken during each survey. Details of sampling procedures and locations of sampling stations will be discussed in subsequent sections of this evaluation.

Parameters measured during the May, 1979, and August, 1979, surveys are generally acceptable descriptors of benthic organism abundance, community structure, and habitat. The applicant provides species counts for

TABLE 26. SUMMARY OF STUDY DESIGNS FOR BENTHIC INFAUNAL SURVEYS

Location	Date	No. Stations	No. Samples	Sieve Size mm	Species List	No. Spp./Sta.	No. Spp./Repl.	Mean No. Spp./Repl.	No. Individuals/Repl.	Mean No. Individuals/Repl.	Sp. Count/Repl.	Mean Sp. Count/Repl.	Percent Sp. Occurrence	Mean Diversity	Mean Evenness	Q-Mode Clusters	R-Mode Clusters	Nodal Analysis	Sediment Size Compos.	Reference
New Bedford Harbor Buzzards Bay	May 1979	5	3	?	X	X	X	X	X	X	X									New Bedford 301(h) application
New Bedford Harbor Buzzards Bay Nasketucket Bay	August 1979	20	3	0.5	X	X				X			X	X	X	X	X	X	X	New Bedford 301(h) application
Buzzards Bay	Oct-Nov 1955	1	1	0.5							X								X	Sanders 1958
New Bedford Harbor Buzzards Bay	Nov 1975	7	2	0.42					X			X								Kelly 1978

Parameters: Species List through Sediment Size Compos.

individual replicate samples taken during the May, 1979, survey, but not for those taken during the August, 1979, survey. Data analyses for the August, 1979, survey included: a) dendrograms of station similarity based on the Bray-Curtis similarity coefficient, b) inverse R-mode cluster analysis of those species occurring in at least 10 percent of the replicates, and c) nodal analysis which produces an integration of Q-mode and R-mode cluster analyses. These classification techniques are potentially useful for detection of pollution impacts on biological communities (Boesch 1977). Detailed evaluation of analytical procedures will be presented in a following section.

Each of the benthic surveys discussed by the applicant was limited in temporal scope. Samples were collected near the existing outfall during only the May, 1979, and August, 1979, surveys. Because the May, 1979, study was a preliminary survey which did not include control stations, the applicant's assessment of benthic communities is based mainly on the August, 1979, samples. The information provided by the applicant is therefore inadequate for characterization of seasonal variation in benthic community structure and species composition.

Sampling Stations and Reference Area Evaluation--The locations of sampling stations occupied during the May, 1979, and August, 1979, surveys are shown in Figures 20 and 21. The applicant gives the coordinates for each station in Table XI-1 of the application. The five stations sampled during May, 1979, correspond to five of the August sampling sites. The following list indicates the relationship of stations sampled during the two surveys:

May, 1979	August, 1979
Station 1	Station B3
2	B4
3	B5
4	B1
5	B6

The applicant states that station positioning was accomplished with a Mini-Ranger III navigation system (Motorola, Inc.) capable of 3 m (10 ft) accuracy at 32 km (20 mi). This method of station location is accurate and generally acceptable for benthic community studies.

The applicant indicates that:

> "Station B1 was located at the site of the applicant's present outfall and Station B2 was 21 m south of the outfall in an area immediately outside the zone of initial dilution (ZID). Station B8 was situated near the proposed improved outfall while Station B7 and B9 were situated north and south, respectively. Stations B17, B19 were located in Nasketucket Bay, to serve as control for the present outfall, and the proposed improved outfall, respectively."

In this statement, the applicant implies that Station B1 was within the ZID and Station B2 was outside the ZID near the ZID boundary. However, station coordinates presented in Table XI-1 of the application and coordinates of the existing discharge provided in Part A, Section 3 of the application, indicate that Station B2 is closer to the outfall than is Station B1 (Table 27). Either the coordinates indicated for Stations B1 and B2 in Table XI-1 are in error or the applicant's description of the relative positions of Stations B1 and B2 with respect to the ZID is incorrect.

If station coordinates in Table XI-1 are correct, then none of the applicant's sampling sites is located within the ZID of the existing discharge. The existing ZID calculated as part of this evaluation is a circle with a radius of 8.8 m (29 ft) (see above, Part B, Section 1). Based on station coordinates provided by the applicant, Stations B1 and B2 are 167 m (548 ft) and 76 m (249 ft) from the outfall, respectively (Table 27), or approximately 158 m (518 ft) and 67 m (220 ft) beyond the ZID, respectively.

According to the applicant's statement quoted above, Station B8 is situated near the proposed outfall site. From Figure 20 and station coordinates provided by the applicant, however, it is apparent that Station B8 is located beyond the ZID of the proposed discharge, about 1.2 km (0.8 mi) from the proposed diffuser. Station B7 is located about 3.1 km (1.9 mi) NNW of the proposed diffuser, and Station B9 is about 2.2 km (1.4 mi) SSW of the proposed diffuser.

TABLE 27. CHARACTERISTICS OF BIOLOGICAL SAMPLING STATIONS, 1979 SURVEYS

Station Group[a]	Station Benthic	Station Shellfish	Station Fish	Water Depth[b] (m) (ft)	Distance to Existing Outfall[c] (m)	Distance to Existing Outfall[c] (ft)	Sediment % Silt + Clay[d]
Outfall	B1	SF5	F5	8.8 (29)	167	(548)	4.5
	B2			8.8 (29)	76	(249)	33.7
Inshore	B4			9.1 (30)	3,398	(11,148)	2.8
	B6	SF4		7.6 (25)	1,400	(4,592)	12.2
	B11	SF2		4.0-4.6 (13-15)	3,192	(10,472)	13.8
	B12	SF3		6.4 (21)	2,377	(7,797)	8.6
	B13			4.9 (16)	3,254	(10,675)	3.3
	B14			6.7 (22)	1,315	(4,315)	54.0
Nearshore Sand	B5			6.1 (20)	2,805	(9,203)	4.3
	B10			2.4 (8)	4,104	(13,465)	1.2
	B16			4.9 (16)	1,901	(6,238)	2.2
Offshore	B3			10.4 (34)	2,527	(8,290)	38.0
	B7	SF12		9.4 (31)	2,657	(8,718)	49.9
	B8	SF14	F14	12.8 (42)	4,809	(15,779)	65.7
	B9			14.9 (49)	6,069	(19,911)	26.1
	B15			8.5 (28)	590[e]	(1,937)[e]	25.0
	B17			6.1 (20)	6,293	(20,646)	29.7
	B18			9.8 (32)	7,903	(25,928)	67.0
	B19			12.2 (40)	8,988	(29,488)	10.3
	B20			13.7 (45)	10,593	(34,753)	52.8

[a] Station groups designated by applicant, based on cluster analysis.

[b] Approximated as nearest sounding(s) or depth contour in Figures XI-1 and XI-2 of the application; also see nautical chart of Buzzards Bay (Chart 13230).

[c] Based on outfall coordinates and station coordinates given in the application following methods of Claire (1973) for conversion to state plane coordinates.

[d] Taken from Table XI-13 of the application.

[e] According to the application text, Station B15 is 640 m (2,100 ft) from the outfall.

The spatial pattern and density of sampling stations within New Bedford Harbor and Buzzards Bay (Figure 20) appears adequate for determination of possible benthic community changes beyond the ZID of the existing outfall. However, only two stations (B1 and B2) are located within 500 m (1,640 ft) of the existing discharge; as noted above, both of these latter sites may be beyond the ZID.

The applicant designates Stations B17 and B19 as control sites for the existing and proposed discharges, respectively. However, the applicant did not sample at the proposed outfall site and fails to discuss the suitability of Stations B17 and B19 as control sites. Therefore, only Station B17 will be evaluated below.

From Figure 20 and NOAA chart 13230 of Buzzards Bay, Station B17 appears to be located approximately 0.6 km (0.37 mi) offshore from West Island and about 1.4 km (0.90 mi) offshore from the mainland at a depth of about 6.1 m (20 ft). Stations B1 and B2 are located about 0.9 km (0.57 mi) and 1.0 km (0.61 mi) offshore, respectively, each at a water depth of 8.8 m (29 ft). Since the existing outfall extends about 1.0 km (0.62 mi) from the shore to a depth of about 8.8 m (29 ft), Station B17 may or may not be a suitable control station for the existing discharge and Stations B1 and B2, depending on local habitat conditions at each site.

Information provided by the applicant on habitat characteristics at Stations B1, B2, B17, and the existing outfall site is limited to data on sediment composition in Table XI-13 of the application (also see Table 27).

Sediment data given by the applicant include median, sorting coefficient, percent silt, and percent clay. Percentages for sand and gravel components are not given, although they appear to comprise substantial proportions of the sediments at many of the applicant's stations. Median sediment grain size at Station B17 was 0.31 mm (0.012 in), which was similar to median grain size at Station B2 [0.29 mm (0.011 in)], but dissimilar to median grain size at Station B1 [0.58 mm (0.023 in)] (Table XI-13 of the application). Based on the data for median grain size, Station B17 appears to be a fair control station for the existing discharge. However, this conclusion is herein considered tentative, pending examination of the complete data set for sediment grain size composition. It should be noted, however, that sediment composition at Stations B1 and B2 could be modified by the presence of the discharge.

On page XI-4 of the application, the applicant states that:

> "In order to physically characterize all stations, measurement of salinity, temperature and dissolved oxygen (D.O.) were made at each sampling location."

The results of these analyses are not presented in the Biological Conditions Summary. Some water quality data for stations in New Bedford Harbor are provided in other sections of the application, but no data are available for Stations B17-B20 in Nasketucket Bay.

As part of this evaluation, Stations B18-B20 were also considered as potential reference sites for the existing discharge site. However, Stations B19 and B20 are located further offshore and in deeper water than Stations B1 and B2 (Figures 20 and 21; Table 27). Station B18, located in water about the same depth as Stations B1 and B2, may be a reasonable control site for the existing discharge, but its sediment composition differs greatly from both Stations B1 and B2 (Table 27).

In discussing the results of the benthic surveys, the applicant does not include pair-wise statistical comparisons of Station B17 with Stations B1 and B2. Since all of the sampling sites are included in a detailed analysis of community similarities, it seems appropriate to consider the suitability of the Nasketucket Bay area as a general location for control stations. Although Nasketucket Bay may receive some domestic sewage from small outfalls, no major sewage discharges comparable in size to the New Bedford discharge are located therein. From the limited information available, it appears that Nasketucket Bay is a suitable reference area for evaluating the effects of the New Bedford existing discharge.

Sampling Procedures--Five replicate samples were collected at each station using a 0.04 m^2 (0.43 ft^2) "modified" van Veen grab sampler. Samples were washed through a sieve having 0.5-mm (0.02-in) mesh openings. The organisms and debris retained by the sieve were fixed in 10-percent formalin and later preserved in 70-percent isopropanol for storage. Three of the five replicate samples were sorted and the organisms enumerated. The remaining two replicates were placed into storage and "are available for processing should greater statistical precision be required."

The applicant's sampling procedures were reviewed during this evaluation and found to be adequate for a qualitative study of benthic infauna. However, accuracy of the applicant's quantitative data appears to have been compromised by the sampling procedures in some cases.

First, the small [0.04 m^2 (0.43 ft^2)], "modified" van Veen grab may not have yielded quantitatively representative samples. Word (1976) analyzed seven types of grab samplers including a normal van Veen grab and a chain-rigged van Veen grab. Word rated the chain-rigged van Veen grab as good for those criteria which affect quantitative samples: variation in surface area sampled, depth of penetration, sample leakage, and pressure wave. The normal van Veen grab was rated good for minimizing variation in surface area sampled and depth of penetration; however, Word (1976) considered it poor with respect to sample leakage and the creation of a pressure wave during descent. If the applicant's modification to the van Veen grab was chain-rigging, then the samples were likely to be quantitatively representative.

The accuracy and precision with which population parameters are estimated depends on the parameter in question and on the size of the sample. The total area sampled among the replicates at each station must be large enough to estimate a given parameter within acceptable limits of accuracy and precision. If the surface area sampled per station is too small, the data will poorly estimate the parameter in question because the ratio of the variance to the mean for a given parameter will be unacceptably large (Gonor and Kemp 1978). Consequently, within-habitat variability (which is a function of nonrandom distribution of the fauna) will obscure differences in community structure when stations are compared.

Holme and McIntyre (1971) and Swartz (1978) recommend that an area of 0.5 m^2 (5.4 ft^2) be sampled in coastal and estuarine regions in order to assess species composition. This recommendation is supported by the results of benthic studies in Puget Sound (Lie 1968). From an analysis of ten 0.1-m^2 (1.1-ft^2) replicates at one site, Lie concludes that a minimum of five replicates is needed to accurately assess species composition, while a minimum of three replicates is required to accurately estimate biomass and numerical abundance.

In light of recommendations by Lie (1968), Holme and McIntyre (1971), and Swartz (1978), it is clear that the applicant's use of triplicate 0.04 m^2 (0.43 ft^2) samples from each station may not have yielded accurate quantitative results. To evaluate the adequacy of the sample size used by the applicant during the 1979 surveys, taxon - area relationships were examined during this evaluation for Stations I (B3), 2 (B4), 3 (B5), 4 (B1), and 5 (B6) sampled during May, 1979 (station designations in parentheses refer to corresponding locations sampled during the August survey, see Figure 20). Sorting data were not available for the August, 1979, survey. Because sampling procedures were similar during the May and August surveys, taxon - area relationships for the May survey should indicate the suitability of the sampling area for both surveys (at least for the five stations sampled during both months). For each station, the cumulative number of taxa collected by replicate sample 1, replicates 1 and 2, and replicates 1, 2, and 3 were determined from sample counts in Table XI-5 of the application. When the cumulative number of taxa is plotted against the cumulative area sampled, the form of the curve indicates the adequacy of the sample size. Failure to approach an asymptote is indicative of undersampling, since a substantial number of new taxa are collected with each successive replicate.

As part of this evaluation, examination of data in Table XI-5 of the application revealed that the first two replicate samples during the May survey included from 77 to 89 percent of the total number of species sampled by three replicates. Taxon - area relationships based on data in Table XI-5 suggest that benthic communities may have been undersampled for determination of species composition at some sites. The applicant's sample size may have been adequate for most quantitative analyses, however. In the absence of data from numerous replicates (e.g., 15 to 20), it is not possible to definitely determine the adequacy of the applicant's sample size for all biological variables and parameters examined.

The applicant's use of a 0.5-mm (0.02-in) mesh sieve for washing samples is adequate for most quantitative analyses. Reish (1959) found that 90 percent of the biomass in his benthic samples was retained on a 1.4-mm (0.06-in) mesh sieve, and 90 percent of the number of species was retained on a 0.7-mm (0.03-in) sieve, but a 0.27-mm (0.01-in) sieve was required to retain 90 percent of the number of individuals in a sample. Holme and McIntyre (1971) recommend a mesh size of 0.5 mm (0.02 in) for macrobenthic studies. Swartz (1978) points out that sieve mesh size should not exceed 1.0 mm (0.04 in). For complete characterization of benthic communities (including juveniles, nematodes, and crustaceans), it may be necessary in some habitats to use a mesh size smaller than 0.5 mm (0.02 in).

Taxonomic Procedures--The applicant briefly describes general taxonomic procedures used during the 1979 survey. Generally, these methods appear to be suitable for a benthic survey. Most taxonomic identifications were to the species level, although the applicant does not describe the qualifications of personnel who identified benthic organisms.

The applicant indicates that the following general taxonomic references were used for the identification of benthic organisms:

Polychaeta:	Pettibone (1963, as cited by applicant), Day (1973, as cited by applicant)
Arthropoda:	Bousfield (1973, as cited by applicant), Williams (1974, as cited by applicant)
Mollusca:	Turner et al. (MS, as cited by applicant), Morris (1973, as cited by applicant)
Other groups:	Smith (1974, as cited by applicant), Miner (1950, as cited by applicant).

The applicant states, "Taxonomic sources for the identification of benthic invertebrates are numerous." Therefore, it may be assumed that additional taxonomic references were consulted. As the applicant's general taxonomic references are commonly used for the identification of benthic invertebrates in the New England region, their use should ensure a reasonably high level of taxonomic precision.

Statistical Analyses--Limited statistical analyses of the May, 1979, data were performed by the applicant, including calculation of mean total number of species and mean total number of individuals collected at each station. The applicant's analyses of the August, 1979, benthic infaunal data include calculation of mean faunal density, species richness, mean Shannon-Wiener diversity, and mean evenness at each station. Based on the August parameter values, stations were ranked and correlation coefficients were calculated for species richness and faunal density rankings, species richness and diversity rankings, and faunal density and diversity rankings.

Diversity was calculated according to the Shannon-Wiener index, H', (Shannon and Weaver 1949):

$$H' = -\sum_{i=1}^{s} p_i \log p_i$$

where:

s = number of species in the sample

p_i = proportion of the ith species in the sample.

The base of the logarithm is not specified; however, base 2 is generally used in the computation of this index. Brillouin's formula for diversity need not be repeated here since the applicant does not present benthic data based on this formula even though the formula is presented in the application.

The applicant calculated evenness (J') using a formula proposed by Pielou (1966):

$$J' = \frac{H'}{\log s}$$

where H' and s are defined as above.

The diversity and evenness indices used by the applicant are suitable for between-site comparisons of benthic communities (see Clifford and Stephenson 1975, Green 1979). However, the applicant did not use available statistical methods (e.g., Hutcheson 1970) for detecting differences between pairs of species diversity values.

The applicant performed both Q-mode and R-mode cluster analyses of benthic infaunal communities. In this analysis, a Bray-Curtis similarity coefficient is calculated between station pairs as follows:

$$S = \frac{2w}{a + b}$$

where:

w = the sum of the lower of the two quantitative values for species shared by the two stations

a = the sum of all values for the first station

b = the sum of all values for the second station

or

$$S_{jk} = \sum_{i=1}^{S} \min (pi_j, pi_k).$$

Similarity is thus the sum of the minimum proportion (or percentage) of each species. The applicant used a standardized Bray-Curtis similarity coefficient and the unweighted pair-group method with arithmetic averaging to construct similarity dendrograms.

The classification analyses performed by the applicant are generally acceptable techniques for benthic surveys. The Bray-Curtis index is probably the most widely used similarity measure (Boesch 1977), and has been shown to reflect true community similarity accurately over a large range of overlap values (Bloom 1981). Boesch (1977) considers the unweighted pair-group method suitable for both R- and Q-mode clustering.

The applicant indicates that the list of species used for the cluster analysis was reduced to eliminate rare species, but the criterion used by the applicant to exclude rare species from the Q-mode analysis are unstated. Improper criteria could result in the exclusion of species that are rare at most stations (e.g., away from the outfall), but abundant at one or two stations (e.g., near the outfall). Such a procedure could bias the results of cluster analysis, such that actual impacts of the discharge would remain undetected.

Examination of Figure XI-5 and Table XI-10 of the application supports the applicant's statement that species were eliminated from the R-mode cluster analyses if they occurred in less than 10 percent of all samples. This is an unacceptable procedure which could lead to biased results. Furthermore, this procedure led to the inclusion of only 33 of the 106 species in the analyses. Since station-specific data on species composition are not available for the August survey, it is impossible to determine the effect of this elimination criterion.

The applicant states further that "The data were log (x + 1) transformed to equalize the contribution of rare and abundant species." Log transformation of the data reduces the weighting of the rare and common species; therefore, the need for removal of the rare species prior to analysis is not apparent. Moreover, the Bray-Curtis similarity coefficient is inherently insensitive to rare groups. Removal of rare species and the subsequent logrithmic transformation may therefore have obscured between-site affinities and differences.

Nodal analysis was performed by the applicant using a measure of species occurrence; i.e., the number of replicates (0, 1, 2, or 3) in which a species was collected is given for each station. It is unclear why the applicant did not employ a more conventional measure of the degree of collection group and species group coincidence, such as the quantitative indices of constancy and fidelity reviewed by Boesch (1977).

The applicant uses a Mann-Whitney U-test to detect differences between station groups in species richness, faunal density, and diversity. The *pooling of station-specific data is based on station groups identified in* the cluster analysis. These are acceptable statistical techniques for determining differences between groups of sampling stations. The suitability of station groups, however, depends on the accuracy of the cluster analysis which was evaluated previously.

<u>BIP Comparisons (Existing Outfall)</u>--The applicant provides an assessment of impacts caused by the existing discharge, based primarily on the results of benthic surveys conducted in New Bedford Harbor, Buzzards Bay, and Nasketucket Bay during May and August, 1979. This assessment depends on a comparison of benthic infaunal communities "near" the outfall with those at other stations presumably removed from the influence of the existing discharge. As discussed earlier in this evaluation, limitations of these studies include:

1. Station B1, which is described as "within the ZID" by the applicant, may be located beyond the ZID of the existing discharge.

2. Station B2, which is described as "immediately outside the ZID" by the applicant, is located about 67 m (220 ft) from

the existing ZID boundary (according to outfall and station coordinates given by the applicant and the size of the existing ZID calculated as part of this evaluation).

3. The bottom area sampled for benthic infauna [total area for three replicates equaled 0.12 m^2 (1.30 ft^2)] may have been too small for accurate estimation of some benthic community parameters measured by the applicant.

4. The studies performed by the applicant do not assess seasonal variation of benthic communities.

5. The applicant does not document the suitability of Station B17 in Nasketucket Bay as a reference site, although Nasketucket Bay appears to be adequate as a location for control stations.

6. The applicant did not sample benthic infauna within the ZID or at the ZID boundary of the proposed discharge.

7. Reference sites were not sampled during the May, 1979, survey.

8. Improper data reduction techniques may have been used throughout the cluster analyses performed by the applicant.

Despite the possible lack of valid BIP comparisons for the existing discharge, it is possible to draw some tentative conclusions from the results of the benthic infaunal studies presented by the applicant. Although the applicant's studies may not have been sensitive enough to detect the severity of impacts within the ZID of the existing discharge, the density of sampling stations through New Bedford Harbor was probably sufficient to characterize the areal extent of impacts, at least for distances from about 590 m (1,937 ft) to 6,069 m (19,911 ft) from the outfall. Recall however that the applicant's calculations based on the August, 1979, samples could not be checked as part of this evaluation because the applicant does not provide species counts for either the individual replicates or the pooled replicates at each station.

The applicant presents a list of 106 taxa collected in the 60 samples taken during the August, 1979, survey (see Table XI-9 of the application). Species are ranked by percent occurrence in the samples in Table XI-10 of the application. The applicant notes that the two most common organisms found in the 1979 survey were the bivalve *Nucula proxima* and the polychaete worm *Nephtys incisa*. It should be emphasized, however, that the percent occurrence data in Table XI-10 are derived from the pooling of all samples from all stations. Therefore, conclusions regarding relative commonness of species at specific sites (e.g., the existing outfall area) cannot be drawn from these data.

Mean values and ranges of faunal density, Shannon-Wiener diversity, and evenness are presented in Table XI-11 of the application (similar data from selected stations are shown here in Table 28). The range of species

TABLE 28. FAUNAL DENSITY, SPECIES RICHNESS, SHANNON-WIENER DIVERSITY (H') AND EVENNESS (J') FOR SELECTED INFAUNAL SAMPLES

Station	Faunal Density		Species Richness		Diversity		Evenness	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
B1	33.0	12-51	10	2-9	1.26	0.92-1.45	0.69	0.44-0.92
B2	6.7	4-8	4	1-2	0.67	0-1.00	0.67	0-1.00
B15	188.0	38-369	24	7-17	2.10	1.23-2.82	0.61	0.44-0.85
B17	149.0	34-370	18	5-10	1.31	0.21-2.16	0.42	0.09-0.65
B18	7.7	4-11	11	3-6	1.96	1.50-2.37	0.91	0.86-0.95

Source: Table XI-11 of the New Bedford 301(h) application.

richness values is also presented for each station, along with the total number of taxa collected in three replicates at each station. The applicant points out that species richness ranged from a high of 25 species in one replicate sample at Station B12 to a low of one species in a sample taken at Station B2 near the existing outfall. According to the applicant, Station B2 samples also contained the fewest numbers of individuals and the lowest diversities relative to samples from other stations. The applicant emphasizes that only the two stations near the existing outfall (Stations B1 and B2) were consistently near the bottom of station rankings for faunal density, species richness, and diversity (also see Table 28). The low species richness values at Stations B1 and B2 were attributed to the impact of the existing discharge, since other stations within the 9.1 m (30 ft) contour displayed richer, denser faunas.

As part of this evaluation, three stations were chosen for comparison with Stations B1 and B2 (Table 28). Stations B17 and B18 are located in Nasketucket Bay at depths slightly less than and slightly more than, respectively, the stations near the existing outfall (Table 27). Station B17 was designated as a reference site for the existing discharge by the applicant. Information from Stations B17 and B18 constitutes the best reference data available for the existing discharge site, although they are subject to limitations discussed earlier (see Sampling Stations and Reference Area Evaluation). Station B15 represents a site in the same general area as Stations B1 and B2 (Figure 20), with a similar water depth (Table 27). Because of its distance from the existing outfall [about 1.3 km (0.8 mi); see Table 27], Station B15 is presumably removed from the immediate effects of the discharge. However, it may not be totally unaffected.

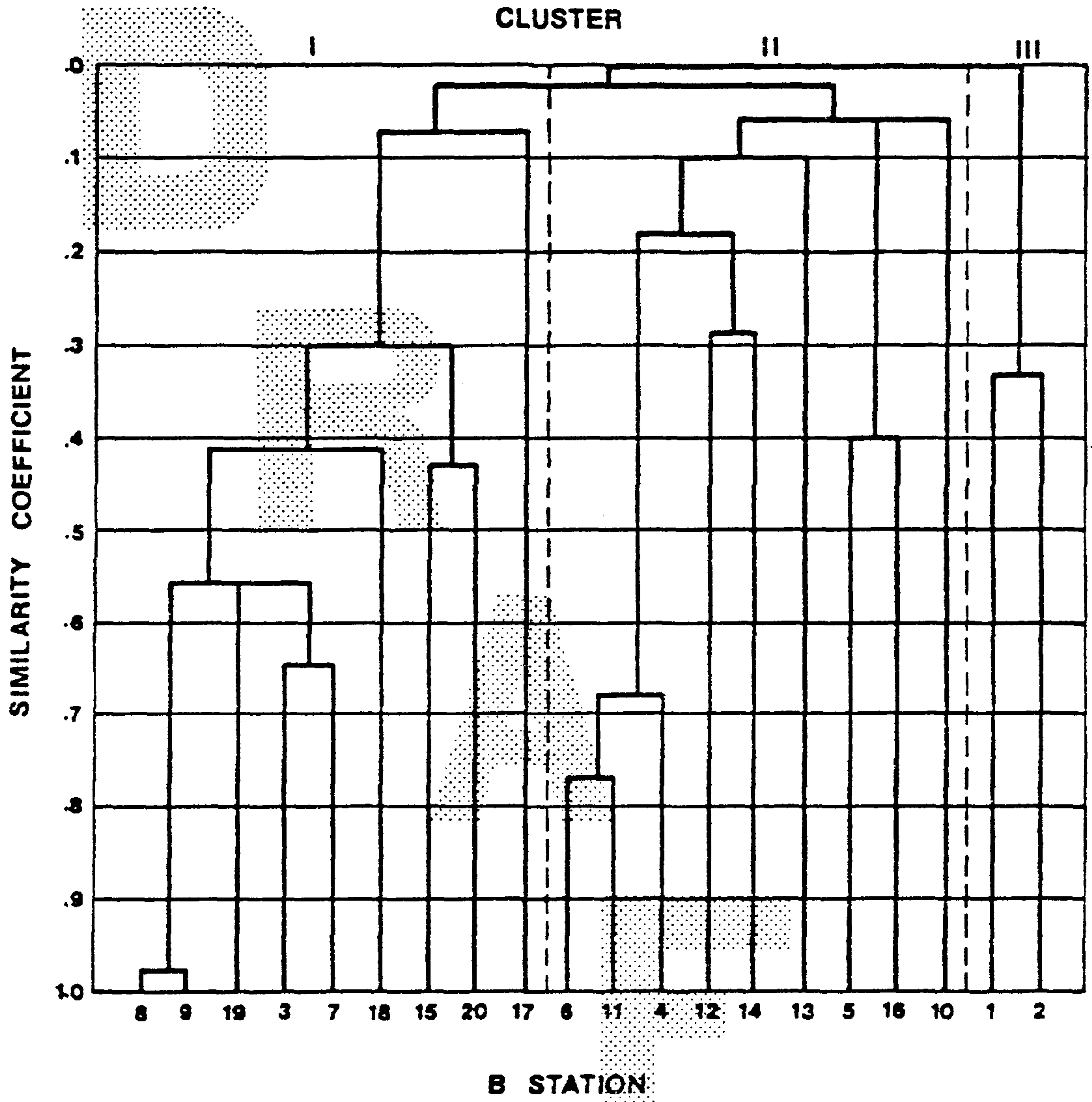
The data in Table 28 generally support the applicant's conclusion that faunal density, species richness, and diversity were low at Stations B1 and B2, compared with other sampling sites. Nevertheless, the data are extremely variable (e.g., diversity and evenness each range from 0 to 1.0 in samples from Station B2). Much of this variation may be due to the small sample size employed by the applicant, which may have precluded quantitative estimates of benthic parameters at some stations (see above, Sampling Procedures). Moreover, the applicant has not determined the statistical significance of the observed differences among stations in faunal density, species richness, diversity, and evenness. Because the applicant has not supplied complete sorting records, the statistical significance of these differences cannot be determined as part of this evaluation.

The applicant reports that Q-mode cluster analysis was performed using all 60 replicates as units in a dendrogram. A second, simplified dendrogram of 20 units was created using only the first replicate at each station. The applicant states that "Comparison of the two dendrograms revealed that all stations appeared in the same orientation." Because only the simplified dendrogram is provided in the application, the applicant's statement cannot be verified. Furthermore, the meaning of the phrase "in the same orientation" is unclear.

As part of this evaluation, examination of data in Table XI-5 of the application revealed that the first replicate samples during the May survey included from 28 to 73 percent of the total number of species sampled by three replicates. This indicates that a single 0.04 m^2 (0.43 ft^2) sample may be inadequate for determination of species composition, species richness, and other analyses (e.g., cluster analysis) dependent on these parameters.

The coincidence of results from the applicant's 60-unit and 20-unit cluster analyses may be an artifact of the small sample size and the procedure used by the applicant to eliminate rare species from the analyses. Also, recall that the applicant does not indicate the criteria used to exclude rare species from the Q-mode analysis. Examination of Table XI-10 and Figure XI-5 of the application supports the applicant's statement that species occurring in less than 10 percent of the samples were eliminated from the R-mode cluster analyses. It was determined earlier that this procedure could possibly bias analytical results (see above, Statistical Analyses).

The results of the Q-mode analysis for the first replicate at each station are shown in Figure 22. Three major clusters, designated here as Clusters I, II, and III, are evident in Figure 22. The applicant notes that Cluster I consists of "...a homogeneous group of stations occupying the deeper offshore sections of the study area...This group includes the proposed outfall location at Stations [sic] B8, as well as the control, Station B19." With the exception of Station B4, Cluster II was considered



REFERENCE: FIGURE XI-4, NEW BEDFORD 301(h) APPLICATION, 1979

Figure 22. Q-mode cluster dendrogram resulting from the first replicate from each macrobenthos station sampled on August 14 - 17, 1979, New Bedford treatment plant, MA.

by the applicant to represent a group of stations located inshore of a line between Wilbur and Round Hill Points, which closely approximates the 9-m (30-ft) contour. Cluster III was defined by the applicant as:

> "The two stations in the immediate vicinity of the applicant's outfall, stations B1 and B2...Statistically this grouping is directly related to the proximity of the outfall. Based upon their location inshore from the 30' contour these stations would be expected to cluster with the second (inshore) large group if the resident fauna were in their natural state."

A dendrogram based on an inverse (R-mode) cluster analysis of those species occurring in at least 10 percent of the replicates was produced and presented in the applicant's biological assessment. Only 33 species of the 106 species collected during August, 1979, satisfied the 10 percent criterion. The applicant states that because this dendrogram is "...more diffuse and difficult to interpret than the corresponding Q-Mode analysis," the groupings were subjected to nodal analysis, "...a technique which allows the integration of Q-Mode and R-Mode cluster analyses into a single figure."

From the nodal analysis, the applicant concludes that the grouping of the outfall Stations B1 and B2 in the Q-mode cluster analysis is probably due more to the lack of a "discernable faunal assemblage" then to shared species. In a discussion of sediment composition, however, the applicant's comments contradict this conclusion:

"...the stations immediately adjacent to the outfall (Stations B1 and B2) exhibit grossly different sediments (4.51% vs 33.74% silt-clay) yet share a common fauna. This indicates that the primary controlling factor for the fauna is not substratum, but rather the the [sic] proximity of the outfall."

According to the applicant, both the R-mode clustering and nodal analyses identified the characteristic *Nucula proxima* - *Nephtys incisa* assemblage which occurs at stations deeper than 9.1 m (30 ft). Another group, characteristic of shallower harbor areas, was attributed to the presence of *Crepidula* species and associated organisms such as the barnacle *Balanus amphitrite*, the scale worm *Lepidonotos sublevis*, and the parasitic gastropod *Odostomia seminuda*. Those stations located at the periphery of the outer harbor in a more sandy area than other stations in the inshore cluster (II) were considered to form a "somewhat discrete subgroup," apparently related to an increased abundance of the bivalve *Solemya velum*, an ostracod, and the polychaete worms *Lumbrineris tenuis*, *Aricidea jeffreysii*, and *Diopatra cuprea*.

Table 29 is a summary of benthic assemblages in the study area according to the applicant. Note that the polychaete *Nereis succinea*, which is the sole dominant at Stations B1 and B2, is not considered a dominant or subdominant at offshore, inshore, or nearshore stations. In their literature review, Pearson and Rosenberg (1978) document that the polychaete worm *Nereis* (= *Neanthes*) *succinea* is considered an opportunistic or pollution-tolerant species in the northeastern United States, although it

TABLE 29. BIOLOGICAL CHARACTERISTICS OF BENTHIC MACROFAUNAL ASSEMBLAGES

	Offshore B3,7-9,15,17-20	Inshore B4,6,11-14	Nearshore B5,10,16	Outfall B1,2
Dominant Species	*Nucula proxima* *Nephtys incisa*	*Crepidula fornicata* *Balanus amphitrite* *Carcinus maenas*	*Lumbrineris tenuis* *Aricidea jeffreysii*	*Nereis succinea*
Sub-Dominants	*Yoldia limutala* *Cylichna oryza* *Tellina agilis*	*Lepidonotos sublevis* *Odostomia seminuda* *Crepidula plana*	*Crepidula fornicata* *Diopatra cuprea* *Lunatia heros*	*Diopatra cuprea*
Species Richness ($\bar{x}$)	15.5	19.2	29	7
Faunal Density ($\bar{x}$)	5,064/m^2	9,080/m^2	2,514/m^2	496/m^2
Diversity ($\bar{x}$)	1.4511	1.6602	2.8054	0.9630

Source: Table XI-12 of the New Bedford 301(h) application.

may not be so throughout its entire zoobiogeographic range. Its occurrence as the only dominant species at Stations B1 and B2 strongly supports the applicant's conclusion that proximity of the outfall is the primary factor controlling benthic community structure at Stations B1 and B2.

The applicant compares species richness, density, and diversity at the stations "immediately adjacent to the outfall (Stations B1 and B2) with values measured at the inshore station cluster (B4, B6, B11, B12, B13, and B14) excluding the nearshore sandy substrate group (B5, B10, and B16). The applicant reports that a Mann-Whitney U-test showed that the "outfall stations" exhibited lower values than the inshore stations for species richness ($P < 0.001$), density ($P < 0.001$), and diversity ($P < 0.01$). The applicant concludes that the "...discharge has resulted in a disruption of normal biological activity in the benthos immediately adjacent to the outfall locations" but notes that this "zone of biological disruption does not extend as far as the next closest station (Station B15), 640 m southeast of the outfall...." The applicant further states that the primary outfall impact is a limitation of "secondary productivity" in an area of at least 25 m (82 ft) but less than 640 m (2,100 ft) from the outfall. Note that the applicant is probably referring to standing stock, not "secondary productivity," here. Secondary productivity of benthic infauna was not measured during the 1979 surveys.

Ignoring for the moment problems of study design and statistical analysis, much of the applicant's interpretation of the benthic infaunal data appears reasonable. However, because detailed records of species counts in individual replicate samples are not provided in the application, neither the applicant's calculations nor the assessment of dominant species for each station cluster (Table 29) can be verified. As discussed earlier in this evaluation, limitations of study design, sampling procedures, and statistical analyses render the applicant's conclusions tenuous at best.

The applicant has not clearly defined a BIP of benthic infauna for the outfall area. Although the applicant makes a distinction between communities "near" the outfall (Stations B1 and B2) and other communities in inshore areas based on cluster analysis, those inshore communities are not necessarily representative of a benthic BIP. Also, the infaunal communities at Nasketucket Bay (Stations 17 and 18, which are possibly the best available reference sites for the existing discharge) were more similar to deep-water communities than inshore sites according to the applicant's cluster analysis (Figure 22). In discussing the sampling locations, the applicant designates Station 17 in Nasketucket Bay as a control for the discharge area. Dominant components of the BIP at this site probably include Nucula proxima and Nephtys incisa (Table 29). In presenting the results of cluster analyses, however, the applicant indicates that Stations B1 and B2 would be expected to cluster with the inshore group of stations "...if the resident fauna were in their natural state."

Evaluation of Specific Biological Perturbations--Certain biological perturbations are not permitted within the ZID of an ocean discharger. Applicable to the benthos are restrictions on the destruction of special habitats of limited distribution, the presence of disease epicenters, and the presence of extreme adverse impacts. As far as is known, no special habitats of limited distribution are located within the ZID of the existing discharge. As discussed previously, however, it is questionable whether or not the applicant sampled benthic infauna within the ZID. In any case, Stations B1 and B2 were at least close enough to the existing outfall to possibly indicate adverse impacts caused by the discharge. Although the applicant's sampling and data analysis is somewhat weak, the conclusions based on the 1979 benthic surveys suggest that the existing discharge has caused major alterations of community structure and species composition within the ZID and possibly beyond the ZID.

Some station-specific data on species composition of benthic infauna are provided in the application. The applicant lists dominant and subdominant species for the station groups identified by cluster analysis (Table 29) and major species groups are associated with collection sites by nodal analysis (Figure XI-6 of the application). However, both of these analyses include only 33 of the 106 species collected by the applicant in the August, 1979, survey. Species restricted to one or a few sampling sites are excluded from those analyses. More complete data are available only for a limited number of stations (including Station B1) sampled during the May, 1979, survey.

In the Biological Conditions Summary, the applicant maintains that *Nereis succinea* and *Diopatra cuprea* are the major species near the outfall. *Nereis* (= *Neanthes*) *succinea* is considered indicative of organic pollution by Pearson and Rosenberg (1978). *Streblospio benedicti*, which was found in two of the three samples taken at Station B1 during the August survey, is also regarded as a species indicative of organic pollution (see references in Pearson and Rosenberg 1978). Capitella capitata, a species commonly associated with sewage pollution (Pearson and Rosenberg 1978), was collected in one of the three samples taken at Station B1 during May, 1979. From the applicant's Table XI-5, Capitella capitata did not appear to dominate the community at Station B1. Nevertheless, in response to Question 7-5 of the Biological Assessment Questionnaire, the applicant indicates that:

> "Benthic communities within the ZID and immediately beyond the ZID (25 m) were dominated by the opportunistic polychaetes Capitella capitata and Nereis succinea, respectively."

It is unclear on what basis the applicant considers C. capitata as a dominant species near the existing outfall.

Kelly (1978; Table XI-8 of the application) documented the dominance of Capitellidae (possibly Mediomastus and/or Capitella) at various sites throughout the New Bedford area. Although Kelly (1978) did not identify polychaetes in his samples to species, Mediomastus ambiseta and Capitella capitata are both known to occur in the study area (see Table XI-5 of the application). Mediomastus ambiseta appears to be a dominant species at Stations B3, B4, and B6 according to the applicant's May, 1979, survey (Table XI-5 of the application).

M. ambiseta is considered dominant in areas of organic oozes, abundant with *Capitella* and *Polydora* on the edges of afaunal areas, and dominant together with *Nephtys* in less polluted areas (see references in Pearson and Rosenberg 1978). On the other hand, *M. ambiseta* was found in only 10 percent of the samples during the August, 1979, survey (Table XI-10 of the application), and it was absent from samples taken at Station B1 during both the May and August, 1979, surveys. *M. ambiseta*, *Capitella*, or *Polydora* were not found in high abundances indicative of excessive organic enrichment.

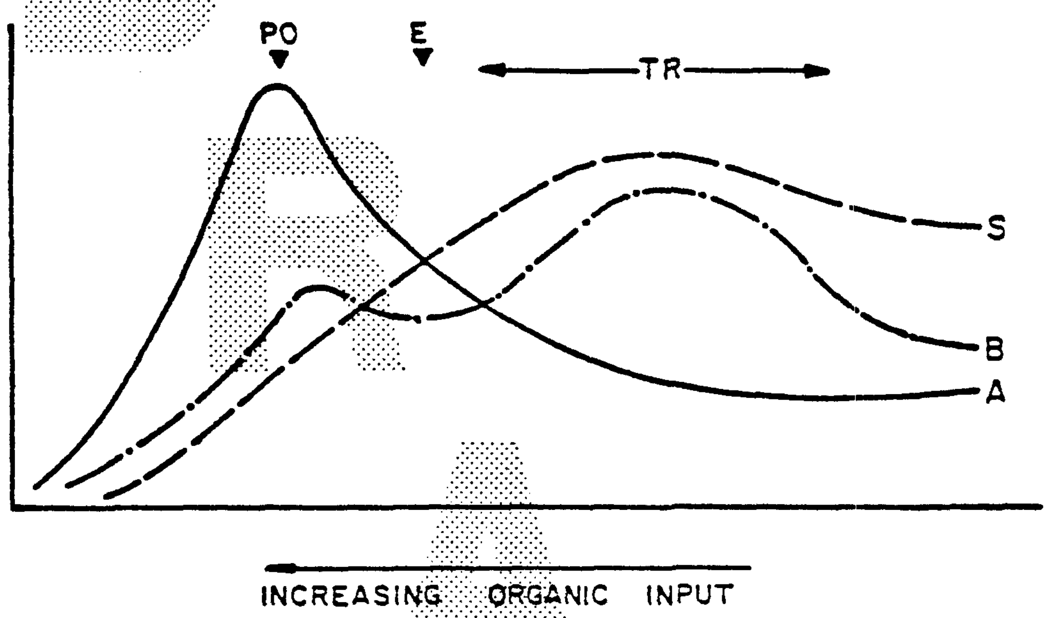
In summary, the dominance of opportunistic polychaete worms (especially *Nereis succinea*) and the low species richness, species diversity, and faunal density observed at Stations B1 and B2 suggest that benthic infaunal communities near the existing discharge may be beyond the "peak of opportunists" associated with an environmental gradient of increasing organic enrichment (see Figure 23 and Pearson and Rosenberg 1978). The areal extent of perturbations caused by the existing discharge cannot be determined precisely because only two stations within several hundred meters of the outfall were sampled.

BIP Predictions (Proposed Outfall)--The applicant indicates that

> "...the extent of the impact for the improved discharge would be limited to the area within the ZID."

and

> "A transitional zone, which may exhibit enhanced productivity due to organic enrichment, may also be found. However, no



S = Species numbers
A = Total abundance
B = Total biomass
PO = Peak of opportunists
E = Ecotone point
TR = Transition zone

From Pearson & Rosenberg, 1978.

Figure 23. Generalized species number, abundance, and biomass diagram showing changes along a gradient of organic enrichment (New Bedford, MA).

adverse impact on benthic populations beyond the ZID would be expected."

The applicant also states that relocation of the outfall "could result in the loss of a small amount of the indigenous Nucula-Nephtys community...." Based on a prediction of enhanced dilution effects at the proposed discharge site relative to the existing discharge area, the applicant expects sedimentation rates of suspended solids from the discharge to be less than natural rates of sediment deposition. The applicant elaborates upon this view in the response to Question 7-13 of the Biological Assessment Questionnaire.

The applicant's assessment of the effects of the proposed discharge is based on: 1) observed impacts of the existing discharge, 2) predicted initial dilutions for the proposed discharge, 3) ocean circulation characteristics at both discharge sites, 4) expected sedimentation rates, and 5) impacts of a "similar" discharge at Point Loma, California. Earlier in this evaluation it was determined that the applicant's interpretation of the benthic survey data was reasonable with respect to assessing impacts of the existing discharge. Nevertheless, the applicant's assessment must be considered tentative because of limitations of sampling and study design associated with the 1979 benthic survey.

The critical average initial dilution for the proposed outfall reported by the applicant is 76 to 1. Under "worst-case" conditions, the initial dilution calculated as part of this evaluation is 60 to 1 for an effluent flow of 2.2 m^3/sec (50.0 MGD) (see above, Part B, Section 1).

The applicant provides no theoretical or empirical basis for predicting that an increase in initial dilution will result in a reduction of impacts on benthic infauna. Sewage discharges generally affect marine benthic communities by causing an increase in the amount of organic material or toxic substances in the sediments near the outfall. Although initial dilution may be one factor affecting localized solids accumulation, other factors such as current speed and the degree of wave-induced resuspension could be expected to have major influences on solids deposition rate per unit area and net solids accumulation. High initial dilution in conjunction with an overall offshore transport do not in themselves ensure that benthic effects will be negligible. Experience at southern California outfalls has revealed relatively large areas [up to 8.3 km^2 (3.2 mi^2)] as having highly modified benthic communities around discharges with initial dilutions ranging from 100-300 to 1 (Mearns and Word, in press).

The applicant's assessment of water circulation at the proposed discharge site is limited to an oceanographic study of about 1 month duration in July and August, 1979. The applicant does not present a detailed discussion of the fate of sewage effluents in the farfield and the plume dynamics which could be expected from current measurements made during the oceanographic study (see above, Part B, Section 1).

The applicant's prediction that sedimentation rates of waste solids will be less than natural sediment deposition rates is unsubstantiated. The applicant fails to compare the solids deposition rates predicted for the proposed discharge with ambient sediment deposition rates. Even if the applicant's assertion concerning relative rates of anthropogenic and natural sediment deposition is correct, there is no evidence to suggest that the resulting impacts on the benthic community would be minimal. In some instances, deposition of sewage solids at rates less than natural sediment deposition rates could cause adverse impacts on benthic communities. Moreover, the quality as well as the quantity of sediment deposited on the bottom will determine the character of biological communities near the proposed outfall.

Finally, the applicant does not provide data on the effects of similar outfalls along the New England coast with the predicted influence of the proposed outfall. Instead, the applicant predicts that the proposed discharge will have no adverse impacts on the BIP of benthic infauna beyond the ZID, based on Bascom et al. (1978) failure to detect degraded areas around the Point Loma (California) outfall. The comparison of the New Bedford proposed discharge with the Point Loma discharge by the applicant is herein considered inappropriate. The two discharges differ greatly not only in their effluent flow rates, but also in their chemical composition. The New Bedford proposed outfall is designed for an effluent flow of 1.31 m^3/sec (30 MGD), whereas the Point Loma outfall presently discharges at an average rate of about 5.3 m^3/sec (120 MGD). Industrial wastewaters account for about 27 percent of the New Bedford discharge, but only 7.5 percent of the San Diego discharge. Although the applicant claims that the two outfalls are located at approximately the same water depth, the Point Loma outfall discharges at 61 m (200 ft), whereas the New Bedford proposed outfall will discharge at about 16.7 m (55 ft). Moreover, shoreline topography and hydrographic conditions at the two discharge sites differ substantially. The two outfalls are also located in entirely different biogeographic zones, each with unique faunistic characteristics. Biological communities at the Point Loma site comprise many component species different from those found in the New Bedford area.

Regardless of the above objections to the applicant's comparison of the Point Loma discharge with the proposed New Bedford discharge, the finding of "no degraded area" at Point Loma is possibly misleading. First, the applicant does not define "degraded". This term has been applied to a specific range of Infaunal Trophic Index (ITI) values (ITI = 0-30) by SCCWRP workers. Word and Mearns (1979) defined control ITI values for the large southern California outfalls to be in the range of 69 to 98.3. However, Bascom (1978) found ITI values between 30 and 60 at the Point Loma discharge site. These ITI values indicate "changed" conditions (Bascom 1978) and are indicative of substantial modifications in infaunal trophic structure resulting from the discharge of sewage effluents.

Although a quantitative relation between initial dilutions or sedimentation rates and impacts on benthic communities cannot be postulated at this time, it seems likely that impacts on benthic infauna caused by the proposed New Bedford discharge will be less than the present effects of the applicant's existing discharge. Upgrading to primary treatment and relocation of the outfall offshore should improve wastewater quality and dispersion. Based on available data, it is impossible, however, to reliably predict whether or not the proposed improvement will eliminate adverse impacts of the existing discharge.

Rocky Intertidal Assemblages--

<u>Study Design</u>--On August 27-28, 1979, the applicant sampled two stations in the rocky intertidal habitat, one site located directly inshore from the existing outfall and a reference station located on West Island. Faunal and floral composition was determined along transects in the high-, mid-, and low-intertidal zones. Species richness and species abundances were measured by a quadrat method. For both macrofauna and algae, community overlap values (Jaccard coefficient) were calculated for the three tidal-height zones.

<u>Sampling Stations and Reference Area Evaluation</u>--The locations of sampling stations used for the intertidal survey are shown in Figure 20 and 21. The applicant does not provide coordinates (latitude and longitude) for the stations, although their positions are briefly described in the text of Appendix XI. Because all intertidal areas near the existing and proposed discharges are beyond the ZIDs of those discharges, comparisons of within-ZID samples with controls do not apply to the intertidal assemblages.

The applicant fails to describe the physical-chemical characteristics of the sampling areas, e.g., substrate types, wave exposures, solar radiation inputs, and distances from pollution sources. These points, among others, should be considered if between-station similarities or dissimilarities are to be quantified and discussed. For example, the position of an ecological zone relative to tidal evaluation may change in response to a pollutant stress and exposure to differing amounts of solar radiation may dramatically affect the algal coverage between sites.

Station I1 appears to be located directly inshore from the existing outfall, in an appropriate area for assessing the effects of the discharge. Station I1 is situated approximately 1.2 km (0.7 mi) north-northwest of the outfall according to Figure 20. Station I2 is located at Rocky Point on West Island, approximately 6.7 km (4.2 mi) east-southeast of Station I1 and more than 6.2 km (3.8 mi) east-southeast of the existing outfall (Figure 21). Station I2 appears to be remote from major sources of pollution, including the applicant's existing discharge. Therefore, it is judged to be an appropriate reference site for evaluating the effects of the discharge. Note that the particular sampling locations chosen by the applicant within the general area of Station I2 may or may not be suitable as control sites, depending on local habitat conditions such as substrate type, wave exposure, and tidal elevation (see below, Sampling Procedures).

Sampling Procedures--At each sampling site, three transects parallel to the shore line were established in the high-, mid-, and low-intertidal zones, respectively. Each transect was sampled at three locations using a 0.25 m^2 (2.6 ft^2) metal-frame quadrat. The applicant indicates that:

"The important environmental factors of tidal elevation, slope, exposure and substrate type were all considered in the selection

> of the reference area. Only flat rock surfaces were used in order to eliminate variability due to differences in substrate characteristics."

The applicant does not describe locations of transects in terms of the "important environmental factors" mentioned above (except substrate inclination as noted).

The application also fails to describe the methods used to locate sampling points along each transect. Subjective choice of sampling points by the investigator could bias the results. The positions of sample units along a transect are normally determined by randomly choosing the sampling locations or by spacing the sample positions evenly along the transect (Gonor and Kemp 1978).

The applicant states that:

> "Large or rare faunal specimens were counted in the entire 0.25 m^2 area; smaller or more dense species were enumerated from four smaller subquadrats. Large macroalgae and sessile macroinvertebrates were sampled for percent coverage with a plexiglass overlay, using a standard random dot method."

The applicant does not indicate the particular species which were enumerated in subquadrats. Data on percent cover of sessile invertebrates is not provided in the application.

The applicant provides no justification for the sample size used in the intertidal surveys. An appropriate sample size is generally determined by one of two criteria: maximization of the number of species retrieved or minimization of the variance of the mean for the parameter in question (Gonor and Kemp 1978). Since the applicant did not provide species counts of fauna in the individual replicate samples, the adequacy of faunal sample size with respect to either the first or the second criterion can not be determined here.

The applicant does not provide details of the "standard random dot method" used to determine percent cover of macroalgae. Since the number of algal species identified by the applicant is extremely limited, it seems inappropriate to evaluate the sample size based on maximization of the number of species collected. As part of this evaluation, the variance of percent cover of Fucus vesiculosus was calculated and compared with the mean percent cover reported in Table XI-22 of the application. Angular transformation of the data was not performed by the applicant (see below, Statistical Analyses). A transformation was not applied to the data as part of this evaluation since the variance does not appear to be a function of the mean (Table 30). Fucus vesiculosus is the only alga for which quantitative estimates of abundance were consistently available at most sampling locations. The variance associated with the applicant's measurements of mean percent cover ranged from 6.2 to 44.1 times the mean (Table 30). These values show an extremely high variance associated with each measurement of mean percent cover, indicating that the applicant's

TABLE 30. VARIANCE ASSOCIATED WITH MEAN PERCENT COVER FOR *FUCUS VESICULOSUS*

Station	Zone	Replicate 1	Replicate 2	Replicate 3	*Fucus vesiculosus* Percent Cover Mean	Variance	Variance/Mean
I1	High	20	33	49	34.0	211	6.2
	Mid	32	97	92	73.7	1,308.3	17.8
	Low	99	2	62	54.3	2,396.3	44.1
I2	High[a]	--	--	--	--	--	--
	Mid	71	56	24	50.3	576.3	11.4
	Low	62	51	0	37.7	1,094.3	29.0

[a] Quantitative data not collected.

sampling procedures were inadequate for determination of percent cover of even the most abundant intertidal algae (cf. Gonor and Kemp 1978).

Taxonomic Procedures--The applicant states that: "Taxonomic sources for the intertidal fauna were the same as those for macrofaunal benthos...Taylor (1957) was the primary reference for macroalgae." The list of taxonomic sources used for fauna was evaluated previously (see above, Benthic Infauna). Although the taxonomic reference sources used by the applicant appear to be generally acceptable, the identity and qualifications of personnel who identified intertidal organisms are not provided in the application. From the lists of fauna and flora in Tables XI-19 and XI-22 of the application, it is apparent that either limited expertise was available to the applicant for identification of intertidal organisms or the scope of the survey was limited to only the most common, easily identified species.

Statistical Analyses--The applicant calculated mean density for faunal species (extrapolated to numbers/m^2) and mean percent cover for the most common floral species. The applicant did not apply any transformation to the percent cover data before determining mean cover. Sokal and Rohlf (1969) note that an angular transformation is especially appropriate for percentages when attempting to normalize a data set. The number of replicate observations (three) made by the applicant in determining percent cover is too small for an evaluation of the normality of the data. Measures of variance about the mean were not determined by the applicant. The total densities of organisms at the two sampling stations are compared statistically, but the specific test is unstated.

For both macrofauna and algae, the similarity of assemblages at the two sampling stations was measured as community overlap using the Jaccard coefficient. This coefficient is an appropriate indicator of community similarity (Boesch 1977). However, the number of macroalgal species quantitatively sampled by the applicant was too small for a meaningful determination of community similarity.

<u>BIP Comparisons</u>--As noted previously, there are no intertidal habitats located within the ZID of either the existing or the proposed discharge. Thus, it is impossible to perform comparisons of intertidal communities within the ZID of either discharge with a BIP characteristic of the biogeographic zone. The applicant compares intertidal assemblages at a station directly inshore from the existing discharge with those at a control site. The studies presented by the applicant provide a limited assessment of impacts on intertidal communities because:

1. A limited number of macrofaunal and algal species were identified.

2. The applicant failed to provide details of faunal sampling procedures.

3. The sampling procedures used to determine percent algal cover were inadequate for accurate estimation of mean percent cover.

The dominant species of intertidal fauna collected by the applicant are shown in Table XI-20 of the application. The barnacle Balanus balanoides was found to be the dominant animal, comprising up to 98 percent of the fauna with an estimated population of up to 84,526 individuals/m^2. The applicant notes that species composition showed little variation between high-, mid-, and low-intertidal zones. For example, six of the seven species collected at Station I1 were considered common to all tidal heights, the remaining species being found at both mid and low elevations. At the reference Station I2, the applicant found eight species representative of the mid and low zones, with four species of the high zone also occurring at the other two tidal elevations.

At Station I1, the applicant notes that "Species richness was similar at all zones (Table XI-19) and was low compared to intertidal studies by Menge (1976)." Only seven species were identified at both the mid and low tidal zone, while six were found at the high elevation. Species richness at Station I2 was found to increase with decreasing tidal elevation; the applicant mentions that this pattern is common in New England rocky intertidal communities according to Menge (1976). However, the applicant does not present statistical comparisons of species richness values among tidal zones or between stations. Based on the low number of intertidal species identified and the small variation of species richness with tidal height and station location (see Table XI-19 of the application), statistically significant differences probably do not exist for between-station or among-zone comparisons.

In contrast to species richness patterns, the applicant found that the total density of animals at Station I1 was significantly less than the total density observed at Station I2 "due to more abundant populations of _B. balanoides_" ($P < 0.05$; statistical test unstated). The applicant suggests that more abundant _Urosalpinx_ populations at Station I1 were responsible for the lesser numbers of barnacles compared with the control site. Since the applicant reportedly observed this carnivorous gastropod in dense aggregations over barnacle patches containing many dead individuals, this hypothesis seems to be a reasonable explanation of the discrepancy in barnacle abundance between stations. The applicant presumably counted only live barnacles and no data on ratio of live to dead barnacles at the two sites are provided in the application.

The similarity of the intertidal fauna at the two stations is shown in Table 31. The results in Table 31 indicated to the applicant that "values were moderate for high and low station comparisons and low for mid sites...."

According to the applicant, "Algal species dominance and community structure were found to be highly similar at Stations I1 and I2." The applicant cites the station overlap values for macroalgae (shown in Table 31) in support of this assertion. However, so few species of algae were identified during the applicant's survey that calculation of the Jaccard coefficient for such data has little meaning.

TABLE 31. COMMUNITY OVERLAP BETWEEN STATIONS FOR INTERTIDAL MACROFAUNA AND ALGAE

Organisms	Tidal Zone	Stations I1 and I2 Jaccard Coefficient (%)	Number of Species in Common
Macrofauna	High	57.14	4[a]
	Mid	41.67	5[a]
	Low	58.33	7[a]
Macroalgae	High	50.00	1
	Mid	75.00	3
	Low	75.00	3

[a] Calculated as part of this evaluation.

Reference: Tables XI-21 and XI-23 of New Bedford 301(h) application.

The applicant found that the brown alga <u>Fucus vesiculosus</u> was dominant at all tidal heights at both sampling sites. No other macroalgae were found at either site, and only three other taxa consisting of red and brown crustose algae and a single species of marine lichen were identified.

From the intertidal data, the applicant concludes that:

> "The above data show no essential differences between stations in species composition, species dominance, species numbers, and community overlap. All differences were minimal and well within the expected range for any two sites selected in the northeast coastal region (Taylor, 1957). No perturbation by the New Bedford outfall is in evidence at either I1 or I2, nor is any predicted from the proposed improved discharge."

Although the intertidal data appear to support the conclusion reached by the applicant, limitations of study design and sampling procedures discussed previously render this conclusion extremely tenuous. Based on the information provided by the applicant, a definitive assessment of impacts on intertidal assemblages caused by the existing discharge is impossible.

<u>BIP Predictions (Proposed Outfall)</u>--The applicant does not discuss the possible effects of the proposed discharge on intertidal communities. Based on an assessment that the existing discharges does not cause impacts on intertidal communities, the applicant predicts that the proposed discharge will cause no perturbations of intertidal fauna and flora. However, the

conclusions reached by the applicant regarding the impact of the existing outfall are extremely tenuous because of limitations of study design discussed previously. Therefore, the applicant's prediction that the proposed outfall will generate no adverse effects on intertidal communities is also weak.

Fishes--

<u>General Study Design</u>--The New Bedford, Massachusetts, 301(h) application is based upon an improved, relocated, ocean outfall. The applicant conducted a 1-day survey for fishes in New Bedford Outer Harbor and Nasketucket Bay on August 15, 1979. Otter trawl sampling was conducted at four stations (see Figures 20, 21). Station F5 included the area within and immediately beyond the ZID of the existing discharge. The existing outfall ZID is a circle with a radius of 8.8 m (29 ft). It is likely that the otter trawl used by the applicant collected fishes both within and beyond the ZID. Because the applicant did not indicate towing speed, the actual area sampled cannot be determined. Therefore, it is not possible to compare the within-ZID fish community with the one occurring immediately beyond the ZID. Water depths at Station F5 range from 8.5 to 8.8 m (28 to 29 ft) at mean low water (MLW) with a substrate characterized as silty sand (see Table 27).

Trawl Station F14 is located beyond the ZID of the existing outfall in the vicinity of the proposed discharge, according to the applicant. This trawl station is approximately 1.2 km (0.8 mi) northwest of the proposed outfall site (Figure A-2 of the application). However, it is possible that Station F14 may be closer to the proposed location when the outfall is actually constructed. The precise location for the proposed outfall awaits further data analysis on ocean bathymetry and substrate composition.

Water depth at Station F14 ranges from 8 to 13 m (27 to 43 ft) at MLW (Buzzards Bay, Chart 13230). At the proposed outfall location, water depth appears to be approximately 13 m (43 ft). Although the trawl appears to have sampled only a small area in water depths less than 13 m (43 ft), the fish collection may be biased by the incorporation of shallow-water [i.e., 8 m (27 ft)] species. Oviatt and Nixon (1973) noted that fish distribution was influenced by water depth in Narragansett Bay, Rhode Island, a system somewhat similar to New Bedford Outer Harbor.

Substrate composition at Station F14 is described as sandy silt (see Table 27). The applicant did not indicate whether a similar substrate exists at the proposed outfall site.

The wide depth zone sampled at F14, the relatively long distance from the proposed outfall, and the lack of outfall sediment data preclude a determination that fishes collected at F14 are representative of those occurring at the proposed site.

Station F11, located inside Nasketucket Bay, is designated as a control fish trawl site for the existing discharge. Water depth at Station F11 ranges from 6 to 8 m (20 to 26 ft) at MLW (Buzzards Bay, Chart 13230) slightly shallower than the depth at the existing discharge Station F5 [i.e., 8.5 to 8.8 m (28 to 29 ft) at MLW]. Substrate composition is not described by the applicant other than noting that fine sand was present at F11. However, based on the depth criterion, this station appears to be an adequate control for the existing discharge.

The fish trawl control station for the proposed outfall, F15, is located in Nasketucket Bay in a water depth of approximately 13 m (43 ft) at MLW (Buzzards Bay, Chart 13230). Substrate composition at Station F15 is not characterized by the applicant. In general, Station F15 appears to be a reasonable control site for Station F14 except for the fact that a portion of the fish trawl at the latter site was conducted in water as shallow as 8 m (27 ft).

<u>Sampling Procedures</u>--The applicant collected fishes using a 4-m (14-ft) semi-balloon otter trawl equipped with weighted oak doors measuring 0.3 by 0.6 m (1 by 2 ft). Body net stretched mesh measured 5 cm (2 in) with a cod end liner stretched mesh of 0.64 cm (0.25 in). The trawl foot rope consisted of 4.8-mm (0.2-in) chain. The height of the head rope with the attached trawl net was estimated to be 1.5 m (5 ft). After undergoing trial tows, a scope ratio of 4:1 proved to be the optimal setting. The otter trawl was towed for 15 minutes at each sampling location. The applicant does not indicate towing speed; thus the area covered by the trawl cannot be reasonably estimated. In general, the trawl gear and procedures employed by the applicant conform to the standards suggested by Mearns and Allen (1978) for coastal biological surveys.

Large fish specimens were identified, enumerated, weighed, and their lengths were measured in the field. Small individuals and fishes requiring further identification were preserved and returned to the laboratory for analysis. All collected fishes were examined for necrotic areas.

Fish identifications were based upon Bigelow and Schroeder (1953), Musick (1973), and Thomson et al. (1971). These are appropriate references for Massachusetts coastal fishes.

Statistical Analyses--The applicant states that classification analysis was performed on demersal fish data. However, no statistical analyses of any type were presented in the application concerning fishes. The extremely limited fish data base compiled by the applicant precludes performing meaningful statistical analyses.

BIP Comparisons--During the 1-day survey in August, 1979, the applicant collected 1,429 fishes representing six species. Although the applicant indicates that length and weight data were recorded for the specimens, the information is not presented in the application.

The largest number of fish (n = 1,322), consisting of only a single species (scup, Stenotomus chrysops), was collected at the existing discharge Station F5. At the existing discharge control station, F11, 10 individuals were collected: 1 northern pipefish (Syngnathus fuscus) and 9 scup. Station F14, in the vicinity of the proposed outfall, also produced two species: 21 scup and a single cunner (Tautogolabrus adspersus). Four fish species were collected at Station F15, the proposed outfall control site. Scup again dominated the catch at this station with 45 individuals collected. The remaining fishes included 17 butterfish (Peprilus triacanthus) 2 black sea bass (Centropristis striata), and 1 red hake (Urophycis chuss).

With respect to anadromous species, the applicant notes that alewives (Alosa pseudoharengus) annually migrate up the Acushnet River via New Bedford Harbor. Reback and Dicarlo (1970) indicate that the river is highly polluted for most of its length through New Bedford, but alewives continue to utilize the system.

The applicant briefly discusses the megafaunal invertebrates which were collected with fishes during the trawl survey. Among the four stations, 24 invertebrate species occurred; however, few individuals of any species were collected. The bivalve, Yoldia limatula, was the most abundant species sampled with only 11 individuals occurring at Station F15.

Given the limited data, it is difficult to determine if the existing discharge has adversely impacted the megafaunal invertebrate community. However, the trawl at the existing discharge station F5 collected the fewest invertebrate taxa (n = 3) and individuals (n = 5) in comparison to the remaining three trawl stations. According to the applicant, this is consistent with the trend observed for benthic infauna at the existing discharge stations.

Little information concerning the indigenous fish fauna in the vicinity of the existing or proposed outfalls is available from the limited survey conducted by the applicant. The applicant notes that scup were common to all the stations, although "migration and schooling behavior of the scup make it an extremely difficult fish to use for environmental assessment." Bigelow and Schroeder (1953, p. 413) indicate that this species is a bottom feeder and displays highly localized distributions over smooth to rocky bottoms. Scup typically migrate into coastal waters in southern Massachusetts during early May and depart to more southerly waters off Virginia and North Carolina in October. The species spawns from May to August, but primarily in June in southern New England (Bigelow and Schroeder 1953, p. 414).

The applicant does not suggest an explanation for the large concentration of scup at the existing discharge Station F5. It is possible that the trawl by chance sampled a school of scup traveling through the existing discharge area. Another possibility is that the fish are attracted to the existing outfall to feed on discharged particulate matter or on benthic prey items. Adult scup prey on crustaceans (particularly amphipods), annelid worms, hydroids, and other benthic invertebrates (Bigelow and Schroeder 1953, p. 413). Juveniles feed on copepods and other small crustacens (Bigelow and Schroeder 1953, p. 413). Oviatt and Nixon (1973) report that shrimp (<u>Crangon</u> spp.), amphipods, and squid were common food items in stomachs of scup collected in Narragansett Bay. Therefore, being an opportunistic feeder, scup may be foraging on the polychaetes

Capitella capitata and Nereis succinea, which dominate the benthic community within the ZID of the existing discharge, or on other invertebrates. Additional investigation is required to determine if scup or other fish species are attracted to the existing outfall.

The applicant discusses the fish surveys conducted by Hoff and Ibara (1977) in the Slocum River estuary south of New Bedford. The average depth of this estuary is 2.2 m (7.2 ft) and salinities range from below 4 ppt to above 28 ppt (Hoff and Ibara 1977). The applicant suggests that a similar fish fauna would be found in New Bedford Outer Harbor and presents a list of species collected by Hoff and Ibara (1977). While four of the six species (i.e., northern pipefish, scup, cunner, butterfish) collected by the applicant appear on the list, it is unlikely that the Slocum estuary fish fauna is representative of that occurring in New Bedford Harbor, given the environmental differences between the two areas (i.e., salinity, depth). For example, the dominant species collected in the estuary by Hoff and Ibara (1977) during the 2-yr study included mummichog (Fundulus heteroclitus, Atlantic silverside (Menidia menidia), fourspine stickleback (Apeltes quadracus), striped killifish (Fundulus majalis) and sheepshead minnow (Cyprinodon variegatus). These are typical New England estuarine species which are unlikely to dominate an open bay environment such as New Bedford Harbor.

A more appropriate reference with which to compare the New Bedford fish fauna is the study conducted by Oviatt and Nixon (1973) in Narragansett Bay, Rhode Island. Scup, butterfish, red hake, and cunner were among the 10 most abundant species collected between June, 1971, and May, 1972. Scup and butterfish were sampled only in the summer and both displayed strong schooling behavior.

Lux and Nichy (1971) reviewed fish trawl data collected during September, 1961, to December, 1962, in Great Harbor, near Woods Hole, Massachusetts, southeast of New Bedford across Buzzards Bay. All six species collected by the applicant were also recorded in Great Harbor. Other similarities are also apparent between the two studies. For example, the greatest number of scup and pipefish were collected during August and September in Great Harbor. Red hake, black sea bass, butterfish, and cunner also occurred predominantly during the late summer and early fall months. Therefore, although the applicant's survey was extremely limited, it appears that the species which were collected are representative of the indigenous southern coastal Massachusetts fish fauna during August.

In summary, given the limited scope of the demersal and pelagic fish study conducted by the applicant, only general, qualitative assessments may be made regarding species composition, abundance, dominance, and diversity of the fish community in New Bedford Harbor. The applicant agrees, stating "Based on the limited fish data no conclusions can be drawn in regard to species at the various stations." The 1-day survey in August, 1979, cannot be employed to elucidate in detail the spatial and temporal distributions of the major fish species. The trawl data are not sufficient to permit a quantitative assessment of fish stocks in New Bedford Harbor. Data on fish growth, reproduction, trophic structure, and productivity patterns are not reported by the applicant. Therefore, given the limitations of the fish survey conducted by the applicant, an adequate assessment of the existing outfall impacts and the potential effects of the proposed outfall on the indigenous fish community cannot be made.

Fish Disease--No evidence of fish disease was apparent on any of the 1,429 fish collected by the applicant during August, 1979. Fish disease has not been previously recorded in New Bedford Harbor[a].

Mass mortalities of menhaden (*Brevoortia tyrannus*) have occurred inside the hurricane barrier of the harbor during 1976, 1977, and 1978[a]. Such kills were also reported in several Massachusetts coastal areas; however, no specific cause has been identified.

Based on these data, the existing outfall does not appear to be a disease epicenter for fish. It is reasonable to assume that with improved effluent treatment and relocation of the outfall, fish disease will not increase.

Commercial and Recreational Fisheries--The applicant presents a brief discussion of commercial and recreational fisheries in the New Bedford area.

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[a] Personal communication (phone) on September 8, 1981, by Mr. M. Griben with Andrew Kolek, Massachusetts Division of Marine Fisheries, Sandwich, MA.

The harbor supports a fishing fleet of over 150 vessels, which in 1976 landed over 28 million kg (63 million lb) of fish valued at $39 million. However, no commercial finfisheries are conducted in New Bedford Harbor or Buzzards Bay because net fishing there is prohibited[a].

Lobster (Homarus americanus) historically supported an important local fishery. Fifty commercial lobstermen used to set pots in the New Bedford Harbor area. The value of the 1977 commercial harvest exceeded $125,000 (Kolek and Ceurvels 1981).

The applicant indicates that popular sport fishes in New Bedford Outer Harbor include bluefish (Pomatomus saltatrix), scup, striped bass (Morone saxatilis), and Atlantic mackerel (Scomber scombrus). Kolek and Ceurvels (1981) report that 100 recreational lobstermen set pots in New Bedford Harbor. The importance of the recreational fisheries in terms of catch and effort is not addressed by the applicant.

Pollution has adversely impacted the fishery resources of New Bedford Harbor. Shellfishing for quahogs (Mercenaria mercenaria) within the inner harbor was prohibited in 1925 as a result of discharges of untreated industrial and domestic wastewater. In 1971, the closed area was expanded

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[a] Personal communication (phone) on September 8, 1981, by Mr. M. Griben with Andrew Kolek, Massachusetts Division of Marine Fisheries, Sandwich, MA.

to include the area north of a boundary line drawn from Ricketsons Point to Clarks Point to Wilbur Point (Figure 24). The basis for this extension of the closed area by the Massachusetts Department of Environmental Quality Engineering (DEQE) was high coliform bacteria counts. According to the applicant, the DEQE attributed this problem to four factors:

- The polluted Acushnet River
- Discharges from at least 30 combined sewer overflows in New Bedford
- The New Bedford and Fairhaven wastewater outfalls
- The lack of reliability of the treatment plants.

PCB contamination has also affected local fisheries. The applicant states:

> "The high PCB levels are attributable to the electrical components manufacturing industry which discharged wastewater containing PCB directly into the harbor until the early 1920's; at which time they connected into the city sewer system and their wastewater was discharged out the 3,300 foot outfall [existing]."

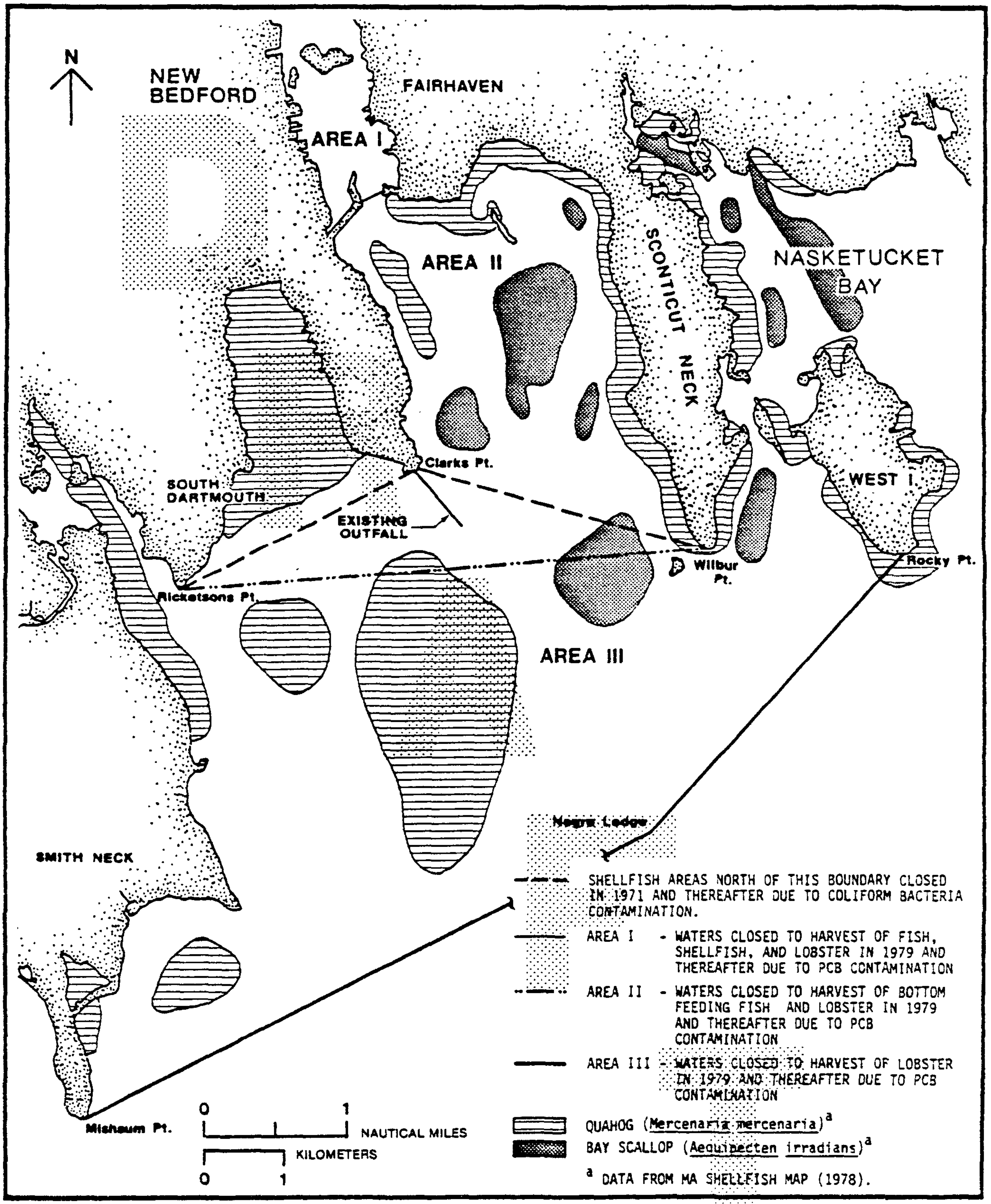

Figure 24. Location of shellfish beds and closed areas in New Bedford Harbor, MA.

According to the applicant, industries discharged most of the PCBs into the Fort Phoenix Beach area of the New Bedford Harbor channel. However, Kolek and Ceurvels (1981) report "Aerovox Corporation and Cornell-Dubilier Corporation, both located in New Bedford, discharged PCBs into the Acushnet River from 1947-1976 and 1942-1976, respectively...."

The applicant indicates that studies conducted by DEQE and the U.S. Food and Drug Administration on PCB levels in quahog clams and lobsters resulted in warnings against human consumption of these species. The area of contamination is north of a boundary line drawn from Ricketsons Point to Buoy 3 at Negro Ledge to Wilbur Point (see Figure 24). According to the applicant, the warning against harvesting and consumption of clams, lobsters, and bottom-feeding fishes was "generally issued only to the commercial lobster and fishing industries. No public notice was ever issued and it is not classified as a 'restriction'."

Kolek and Ceurvels (1981) report that the Massachusetts Division of Marine Fisheries (MDMF) began analyzing New Bedford Harbor fish, shellfish, and crustaceans for PCBs in September, 1976. In March, 1977, the Massachusetts Department of Public Health (MDPH) issued a warning against consuming bottom-feeding fishes caught in New Bedford Harbor because PCB levels in fish tissues exceeded the 5 ppm Federal Action Level. On June 2, 1977, a second warning covering lobster was issued by the MDPH. An actual closure order was issued by MDPH on September 25, 1979. The order classified the harbor into three areas: Area I, inner harbor north of hurricane barrier, was closed to the taking of all fishes, shellfish, and lobsters; Area II, waters south of Area I and north of the boundary line extending from Ricketsons Point to Wilbur Point, were closed to the taking of bottom-feeding fishes; and Area III, waters south of Area II and north of the boundary line extending from Mishaum Point to Buoy 3 at Negro Ledge to Rock Point, were closed to the taking of lobsters (Kolek and Ceurvels 1981). This closure notice was announced to the local media (Kolek and Ceurvels 1981). Apparently this closure announcement was published after the applicant had submitted its 301(h) application.

The applicant states that only trace levels of PCBs occur currently in the New Bedford effluent at the existing outfall. While trace amounts of PCBs may continue to be discharged at the proposed outfall, the applicant believes that no adverse impacts on fish or shellfish should occur. No data are provided to substantiate this contention. Extensive monitoring of the fishery resources at the proposed site should be undertaken to investigate impacts of low-level PCB contamination. Further details concerning PCB contaminaton in New Bedford Harbor fishery resources are provided in the Bioaccumulation section of this evaluation.

The improved treatment of the effluent discharged through the proposed outfall should reduce the total coliform bacteria counts, and thus not adversely impact shellfish, according to the applicant. This is a reasonable assumption.

In summary, the available information indicates that there is no commercial fishing in the vicinity of the existing outfall. However, it is likely that commercial lobstering is conducted in the area of the proposed outfall. Recreational fisheries apparently do occur in New Bedford Outer Harbor, but no information on the importance of these fisheries is available. Contamination of the available fishery resources by PCBs and by coliform bacteria limit fishing opportunities in New Bedford Harbor. The existing outfall has likely contributed to harbor pollution; however, the extent of the discharge's impact remains to be quantified. It is likely that with improved treatment of the effluent discharged through the proposed outfall, coliform bacteria levels should be reduced. However, the trace amounts of PCBs present in the effluent currently are likely to occur also in the effluent discharged at the proposed outfall site. The effect of low-level PCB contamination on fishery resources warrants further investigation prior to concluding that no adverse effects will occur.

Shellfish--

General Study Design--The applicant sampled shellfish at 20 stations located in New Bedford Harbor and Nasketucket Bay during August 14-17, 1979 (see Figures 20 and 21). According to the applicant, these sites were sampled "to examine population densities at the outfall and surrounding areas, with control sites in Nasketucket Bay." Stations were located using Loran A.

Station SF5 included the area within and immediately beyond the ZID of the existing discharge. The existing outfall ZID is calculated as a circle with a radius of 8.8 m (29 ft). Water depth at SF5 ranges from 8.5 to 8.8 m

(28 to 29 ft) at mean low water (MLW) (Buzzards Bay, Chart 13230). The substrate in the vicinity of Station SF5 appears to be silty sand. Sediment samples at Stations B1 and B2 (see Figure 20) have silt and clay contents of 4.5 and 33.7 percent for the two stations, respectively (see Table 27). Therefore, the substrate in the vicinity of the existing discharge is not homogeneous. Because the shellfish dredge was probably dragged over a considerable distance (n.b. applicant did not indicate the area sampled), organisms preferring specific sediment types may have been combined in the sample taken at Station SF5. Therefore, it is difficult to determine if differences exist between shellfish assemblages within and immediately beyond the ZID.

The applicant designates two stations as lying beyond the ZID of the existing discharge. Station SF4 is located approximately 0.9 to 1.1 km (0.5 to 0.6 nmi) northeast of the existing discharge in a water depth of 7.6 to 8.2 m (25 to 27 ft) at MLW (Buzzards Bay, Chart 13230). The applicant reports a sediment median grain size of 0.46 mm (0.02 in) and a silt and clay percentage of 12.2 (i.e., silty sand) for benthic Station B6, located near Station SF4 (see Figure 20, Table 27). Station SF20 is slightly farther from the existing outfall [approximately 1.1 to 1.7 km (0.6 to 0.9 nmi) to the southwest] than is Station SF4. Water depth at Station SF20 is about 7.1 m (23 ft) at MLW. The applicant did not characterize the sediments at this site. The NOAA Buzzards Bay chart 13230 describes the substrate as sticky in the vicinity of Station SF20.

Station SF14 is located in the vicinity of the proposed discharge according to the applicant. This station is approximately 1.2 km (0.8 nmi) northwest of the proposed site as designated on Figure A-2 of the application. However, it is possible that Station SF14 may be closer to the proposed location when the outfall is actually constructed. The precise location for the proposed outfall awaits further data analysis on ocean bathymetry and substrate composition.

Water depth at Station SF14 ranges from approximately 8.2 to 13.1 m (27 to 43 ft) at MLW (Buzzards Bay, Chart 13230). Although the shellfish dredge appears to have sampled only a small portion of the bottom in water less than 13.1 m (43 ft), the shellfish collection may be biased by the incorporation of shallow water [i.e., 8.2 m (27 ft)] species. For example, the habitat of the quahog clam, Mercenaria mercenaria, extends from the littoral zone to 11.9 m (39 ft) depth while the false quahog, Pitar morrhuana, is distributed in water depths ranging from 4.0 to 32.9 m (13 to 108 ft) (Gosner 1971, p. 301). While these species have overlapping distributions, it is likely that each species is more abundant within a narrower depth range. Optimally, the dredge should have sampled within a more homogenous depth zone.

Benthic Station B8 was located along the dredge track of SF14. Sediment analyses at B8 revealed a sandy silt substrate (see Table 27). The applicant does not indicate if a similar substrate exists at the proposed outfall site. Given the relatively long distance from the proposed location and the absence of sediment data, it is difficult to conclude that shellfish collected at SF14 are representative of those occurring at the proposed site.

Station SF11, located inside Nasketucket Bay, is designated as a control shellfish site for the existing discharge. Water depth at Station SF11 ranges from about 6.1 to 8.9 m (20 to 26 ft) at MLW (Buzzards Bay, Chart 13230), somewhat shallower than the depth at the existing discharge Station SF5 [i.e., 8.5 to 8.8 m (28 to 29 ft) at MLW]. Substrate composition is not described by the applicant other than noting that fine sand was present at the site. Without additional data it is difficult to determine if Station SF11 is an adequate reference site for the existing discharge, Station SF5.

The shellfish control station for the proposed outfall, SF15, is located in Nasketucket Bay in a water depth of approximately 13.1 m (43 ft) at MLW (Buzzards Bay, Chart 13230). Substrate composition at Station SF15 is not characterized by the applicant. Therefore, it is also difficult to conclude that SF15 is an adequate control site for the proposed outfall location.

Overall, the limited information provided by the applicant on the substrates at the various shellfish stations makes it difficult to reasonably compare the collections made at each sampling site. Differences in water depth and substrate composition among the shellfish stations may have introduced biases which preclude determining if the existing discharge has impacted the indigenous shellfish fauna.

Sampling Procedures--A commercial clam dredge was used to sample shellfish at each station. According to the applicant, "tows were made from two (2) to ten (10) minutes, depending upon the expected densities at the sites." This is not an appropriate method for sampling surveys. The applicant does not specify the area sampled by the dredge or the towing time at each station. Therefore, it is unknown whether stations where large numbers of individuals were collected represent areas of high density or whether these large catches simply are an artifact of extended towing time. To allow reasonable comparisons among sampling locations, the applicant should have standardized towing time (i.e., sampling effort) at each station.

Specimens collected in the dredge were identified to species and enumerated in the field. According to the applicant, "A representative sample of each species was kept...." The applicant does not indicate the method employed for sample preservation or the taxonomic references used for identifying the specimens.

The sampling procedures employed by the applicant do not permit reasonable comparisons to be made among sampling locations to evaluate the impacts, if any, of the existing discharge.

Statistical Analyses--The applicant employs classification analysis (normal, Q-mode) to examine the overall "likeness" of shellfish assemblages among each of the 20 sampling stations. The standardized Bray-Curtis similarity coefficient is utilized in the analysis and the unweighted pair-group method using arithmetic averages (UPGMA) is employed to construct a dendrogram. The applicant indicates that these procedures have been widely used in ecological research. The UPGMA method was employed since it has the dual advantage "...of producing moderately sharp clustering while introducing relatively little distortion into the original relationships expressed in the similarity matrix." This conclusion is supported by a preliminary study conducted by Cunningham and Ogilvie (1972).

In general, these numerical classification techniques are applicable to ecological investigations where complex data sets require simplification to enhance data interpretation (Boesch 1977). The problem in applying these methods to the shellfish data is the extremely limited data base. Although 16 invertebrate species were collected during the dredge survey, the applicant limited the analysis to only two species, Mercenaria and Pitar because "this dredge is designed to collect quahogs [Mercenaria] and associated infaunal bivalves...." Boesch (1977) recommends that because intuitive exclusion criteria are often multivariate in nature "it is reasonable to impose several criteria in making decisions on exclusion." Therefore, the applicant should have provided additional reasons for excluding the remaining species or should have utilized another method of analysis. For some species, the applicant indicates only species presence, which cannot be subjected to quantitative analysis.

The applicant indicates that a logarithmic transformation, i.e., log (x + 1), was employed "to equalize the contribution of rare and abundant species." This is an appropriate technique (Boesch 1977). However, since only two species which commonly occurred in the shellfish samples were selected for analysis, it is unclear whether the transformation was applied.

In summary, there appears to be little justification for employing classification analysis on data for only two species. Boesch (1977) and Stephenson (1973) both indicate that there is little to gain from numerical classification of small data sets where ecological relationships are more intuitively apparent. According to the applicant, the shellfish cluster analysis dendrogram reveals two main station groups with three sites showing "little affinity with either of the groups." Because only two species were employed for the analysis, the resemblance among stations appears to be based upon the total number of Mercenaria and Pitar collected at each site. Therefore, the dendrogram does not appear to enhance the ecological interpretation of the shellfish data.

Numerical classification is the only quantitative method applied to the shellfish data. The limited data set and the unequal sampling effort at the various sites precludes performing any type of meaningful statistical analyses on the shellfish data.

BIP Comparisons--Sixteen invertebrate species were collected at 20 stations during the shellfish survey. Four of the species [i.e., boring sponge (Cliona celata), parchment worm (Chaetopterus variopedatus), slipper shells (Crepidula fornicata, C. plana)] were recorded as being present, i.e., the number of individuals occurring in the dredge samples was not indicated. Mercenaria was the dominant bivalve species collected during the survey (n = 5,137), followed by Pitar (n = 241), oysters (Crassostrea virginica) (n = 30), blood arks (Anadara ovalis) (n = 2), and bay scallops (Aequipecten irradians) (n = 1). Mercenaria occurred at all stations except SF15, the control site for the proposed outfall in Nasketucket Bay.

Pitar occurred at fewer stations than did Mercenaria, but there does not appear to be a pattern to the species distribution in New Bedford Harbor. The largest quantity of Pitar (n = 110) was collected at Station SF14, where water depth ranges from 8.2 to 13.1 m (27 to 43 ft). The wide depth range sampled at this station precludes determining if the species was collected at all depths or only over a certain portion of this range. Specimens of this species were also found at Stations SF1 (n = 40) and SF4 (n = 36). Water depth at the former station ranges from 2.7 to 4.9 m (9 to 16 ft) and at the latter site from 7.6 to 8.2 m (25 to 27 ft). Therefore, it is difficult to determine from the data if Pitar inhabit specific depth zones or if they are ubiquitous throughout New Bedford Harbor.

Oysters were found only at the inner harbor stations, SF1 (n = 5) and SF2 (n = 25), where depths range from 2.7 to 4.9 m (9 to 16 ft).

The spider crab (Libinia emarginata) was the third most abundant (n = 150) invertebrate species collected during the shellfish survey. In general, spider crabs occurred in the shallower portions of New Bedford Harbor. A second crab species, the blue crab (Callinectes sapidus) (n = 5), was collected only at Station SF3.

The remaining species were rarely encountered during the shellfish survey. These included horseshoe crab (Limulus polyphemus) (SF17, n = 1), channelled whelk (Busycon canaliculatum) (SF3, n = 5; SF10, n = 4; SF20, n = 8), knobbed whelk (Busycon carica) (SF20, n = 2), lobed moon shell (Polinices duplicata) (SF9, n = 1), and starfish (Asterias forbesii) (SF10, n = 14).

Further analysis of the shellfish data is precluded by the unequal sampling effort employed during the survey (see Sampling Procedures). Without additional information on area sampled and dredging time at each station, it is unknown whether the species abundances reported by the applicant indicate areas of high density or are simply an artifact of sampling effort.

According to the applicant, the dendrogram based on the collection of Mercenaria and Pitar reveals two main station groups with three sites showing little similarity to either group (Figure 25). The most similar group, with all members having a standardized Bray-Curtis similarity coefficient of 0.4 or greater, included Stations SF1, SF3, SF4, SF5, SF6, SF7, and SF16. The applicant indicates that these stations are all located in closed shellfishing waters where bottom substrates are hard. The sediment data provided by the applicant are insufficient, however, to determine if substrates are in fact hard at these sites. Substrates at Stations SF3, SF4, and SF5 are considered silty sands (Table 27). The apparent similarity of these stations appears to be due to the abundance of

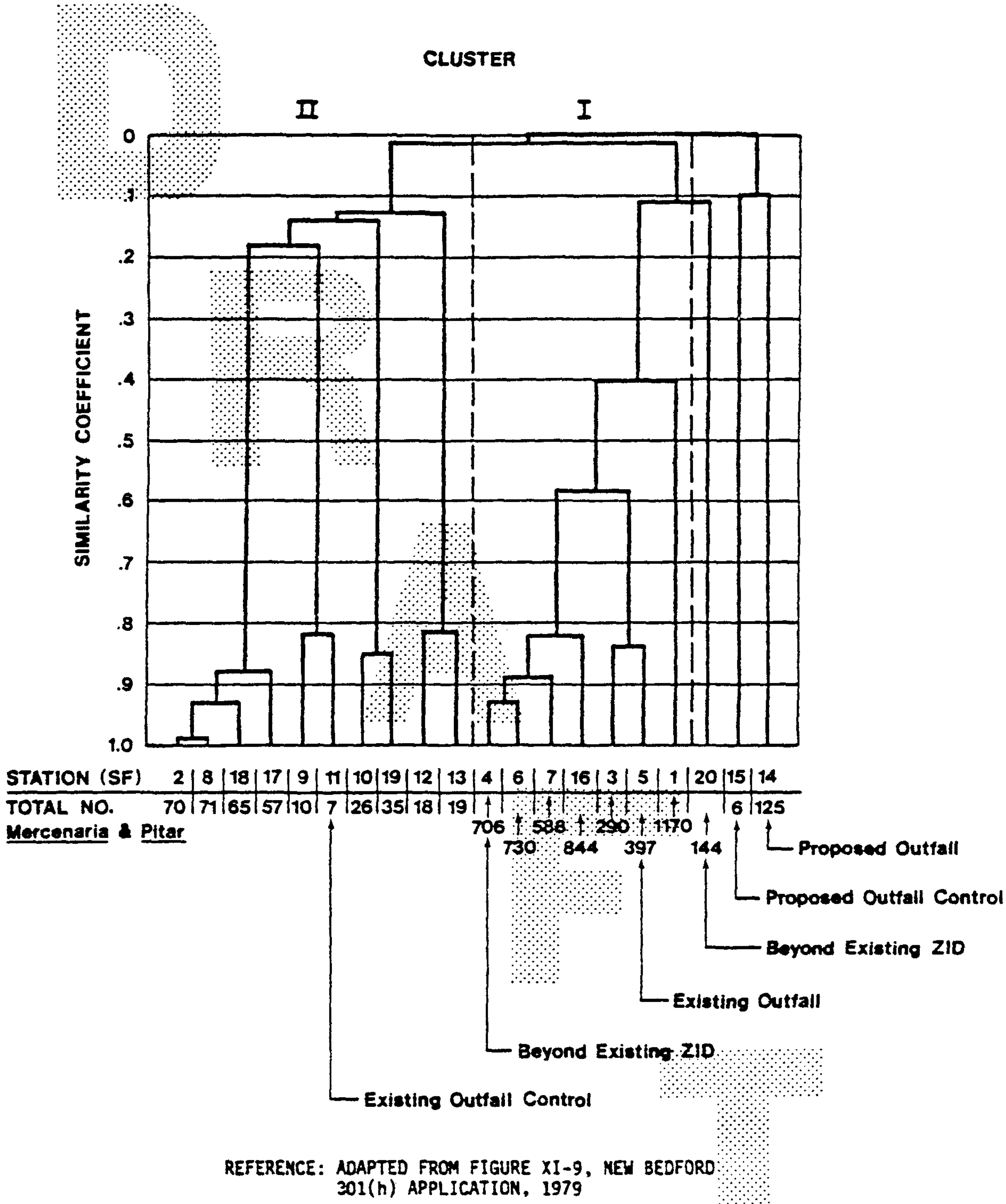

Figure 25. Q-mode cluster dendrogram for shellfish collected at 20 stations in New Bedford Harbor and Nasketucket Bay, MA, August 14 - 17, 1979.

Mercenaria. The number of Mercenaria collected at these stations ranged from 290 (SF3) to 1,130 (SF1). The existing discharge site, SF5, is included in this group. Although the beyond-ZID station, SF4, clustered with SF5, the control site, SF11, did not. The small number of Mercenaria collected at SF11 probably accounts for its lack of similarity with SF5.

The second major station group, according to the applicant, includes Stations SF2, SF8, SF9, SF10, SF11, SF12, SF13, SF17, SF18, and SF19. These stations were less similar, one to another, than were those in the other major group. The final three joinings in this cluster only had standardized Bray-Curtis similarities of between 0.1 and 0.2 (Figure 25). It is difficult to assume that these stations are reasonably similar given such a low coefficient. The applicant states that these stations "are, with one exception, either located in bottoms other than hard or are in legally fishable waters." The applicant did not further specify substrate composition for each station other than to note that "fine sand was present" at Station SF11. Based on sediment analyses near SF2, the substrate is considered silty sand, similar to substrates encountered at Stations SF3, SF4, and SF5 (Table 27). In contrast, the substrate at SF12 is characterized as sandy silt (Table 27).

The three stations which were not considered similar to either of the two groups or to one another included SF14 (vicinity of proposed outfall), SF15 (proposed outfall control), and SF20 (existing outfall, beyond ZID). The applicant notes that Pitar was present at the first two sites; in fact, the largest collection of the species (n=110) was made at SF14. The applicant also indicates that these stations represent the deepest dredge sites. The shellfish sample at Station SF20 was composed exclusively of Mercenaria (n=144). The applicant could not explain its low affinity with either of the two main station groups.

The applicant was not able to detect other patterns among stations within other station groups. The applicant states "The general scarcity of Pitar and Mercenaria in Nasketucket Bay is probably due to sediment type and increased siltation due to the polychaete Chaetopterus." The applicant cites an unpublished study which "indicated a general degradation of the bottom when the study site was invaded by Chaetopterus...." Although the polychaete was collected in Nasketucket Bay, the applicant did not demonstrate that it had "invaded" the area and modified the bottom sediments. A more reasonable explanation is that the applicant located sampling stations in areas of low Mercenaria abundance. A map entitled Shellfish Resources of the Massachusetts Coast (1978) indicates that there are extensive Mercenaria beds located along the eastern shore of Sconticut Neck, and also along Fairhaven and West Island beaches.

The applicant summarizes the shellfish discussion by stating: "Results from the dredge are inconclusive with regard to effects of the [existing] outfall on the quahog [Mercenaria] population." The applicant contends that if there are impacts attributable to the existing discharge, they are obscured by "natural variation and substrate preferences, and the commercial fishery...." The data presented by the applicant are insufficient to substantiate this conclusion.

No information was provided indicating the natural variability of the indigenous shellfish species in New Bedford Harbor, nor were species substrate preferences indicated. The applicant did not describe the commercial shellfishery with respect to catch and effort nor were details provided on specific harvesting areas.

In summary, the applicant did not demonstrate that the shellfish community in the vicinity of the existing discharge, SF5, was similar to the one encountered at the designated control site, SF11. For stations located beyond the existing ZID (SF4, SF20) and in the vicinity of the proposed outfall (SF14) and control (SF15), little similarity was noted. The shellfish data collected by the applicant are inadequate to reasonably evaluate the impact, if any, of the existing discharge or potential effects of the proposed outfall on the indigenous shellfish community of New Bedford Harbor. However, the species which were collected are typical of those expected in New England coastal waters.

Bioaccumulation--

The applicant presents results of studies of chemical analyses of sediments and organism tissues (shellfish) in Appendix XVII.

Sediment Analyses--The applicant presents results of several sediment studies conducted in Buzzards Bay and New Bedford Harbor during the period of 1971-1975. These studies (New England Aquarium 1973; Water Resources

Commission 1972; Massachusetts Division of Water Pollution Control 1975; all not seen) are unpublished reports which could not be reviewed as part of this evaluation.

The results of a 1979 study of sediment and tissue concentrations by Camp Dresser and McKee, Inc. (CDM) are also presented. The analytical methods used in this study (CDM) are referenced by the applicant and are considered appropriate for the indicated analyses.

Eleven stations sampled by CDM correspond to the following location categories: within-ZID, S1; beyond-ZID, S2, S10, S11, S12; control, S17, S18, S19, S20; proposed outfall, S8, S9 (Figures XVII-1A and XVII-1B of the application). The locations of the "S" stations used for sediment analyses appear to be about the same as the "B" stations described in the Benthic Infauna subsection above (Figures 20 and 21).

Based on the CDM studies and previous studies in the area, the applicant concludes that for the sediment samples, "Concentrations of metals were generally highest at stations located near the ZID...." The applicant also concludes that sediment metal concentrations were similar among stations located beyond the ZID (exclusive of the near-ZID station, S2). Evaluation of the data supplied by the applicant supports these basic conclusions. Concentrations in the sediments of metals typically associated with sewage effluents (Cd, Cr, Ni, Pb, Zn, Ag, and Hg) were much higher at ZID and near-ZID stations when compared with control areas, outer harbor sites, and the proposed outfall location (Table 32 and application Tables XVII-13, XVII-14, and XVII-15).

TABLE 32. SEDIMENT CONCENTRATIONS (mg/dry kg) OF SELECTED METALS AND PCB NEAR THE NEW BEDFORD OUTFALL

Station	PCB	Cadmium	Chromium	Nickel	Lead	Zinc	Silver	Mercury
ZID	8.75	25.0	210	9.95	750	550	0.270	0.154
Near-ZID	27.0	56.5	515	46.5	715	995	0.770	0.478
Control (median)	ND	0.365	36.0	8.38	40.5	50.5	0.55	0.022
Proposed Outfall (median)	ND	0.270	31.8	8.3	34.5	41.8	<1	0.034

Source: Application Table XVII-15.

In a study of metal contamination of sediments throughout New Bedford Harbor and parts of Buzzards Bay, Stoffers et al. (1977) describe the harbor as a "leaky sink" for contaminants. Sediments near the head of the harbor in the Acushnet River estuary had the highest levels of contamination, with copper concentrations exceeding 5,000 ppm. There is a gradual seaward decline in sediment metal concentrations; however, Stoffers et al. (1977) conclude that sediments are "slightly contaminated" even at the proposed discharge site.

Sediment PCB concentrations at the near-ZID station (S2) were approximately two orders of magnitude higher than concentrations at the New Bedford harbor sites S10, S11, and S12. This pattern suggests that the outfall may be a significant source of PCB contamination since the harbor sites are considerably closer to other known point sources of PCBs.

It is interesting to note that for most metals and PCBs, considerably higher sediment concentrations were measured at the near-ZID station (S2) than at the ZID station (S1). The applicant does not provide station coordinates for the sediment stations, but only displays locations on application Figures XVII-1a and XVII-1b. Based on the applicant's maps, it is not possible to confirm the station designations. It is important to note, however, that Stations S1 and S2 are shown by the applicant in similar (although slightly different) locations as benthic stations B1 and B2. In the Benthic Infauna subsection of this evaluation it was shown that the applicant's station coordinates for B1 and B2 do not agree with their location designations (i.e., ZID and near-ZID, respectively). The coordinates of these stations place the putative near-ZID station closer to the outfall than the putative ZID station. It is possible that a similar miscalculation was made for the sediment station locations; thus, the higher concentrations at Station S2 could reflect the fact that Station S2 may be closer to the outfall than is Station S1.

Several of the sediment stations near New Bedford were sampled in 1971 and 1975. At the site nearest the existing outfall (NB_3, application Table XVII-13) several sediment constituents (Hg, Pb, Zn) displayed reductions in concentration between 1971 and 1975. Alternatively, chromium and nickel both displayed increased concentrations in 1975 relative to 1971. At the harbor site (NB_5), mercury and lead also declined from 1971 to 1975, while concentrations of zinc, nickel, and chromium increased.

As part of this evaluation, recent sediment PCB data were obtained from the Massachusetts Department of Environmental Quality Engineering (DEQE)[a]. The locations of selected DEQE stations are shown in Figure 26. With the exception of the Acushnet River sites (1 and 1A), the New Bedford sewage

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[a] Personal communication (written response to phone request) on September 11, 1981, by Mr. M. Griben with Mr. Richard Packard, Massachusetts Department of Environmental Quality Engineering, Lakeville, Massachusetts.

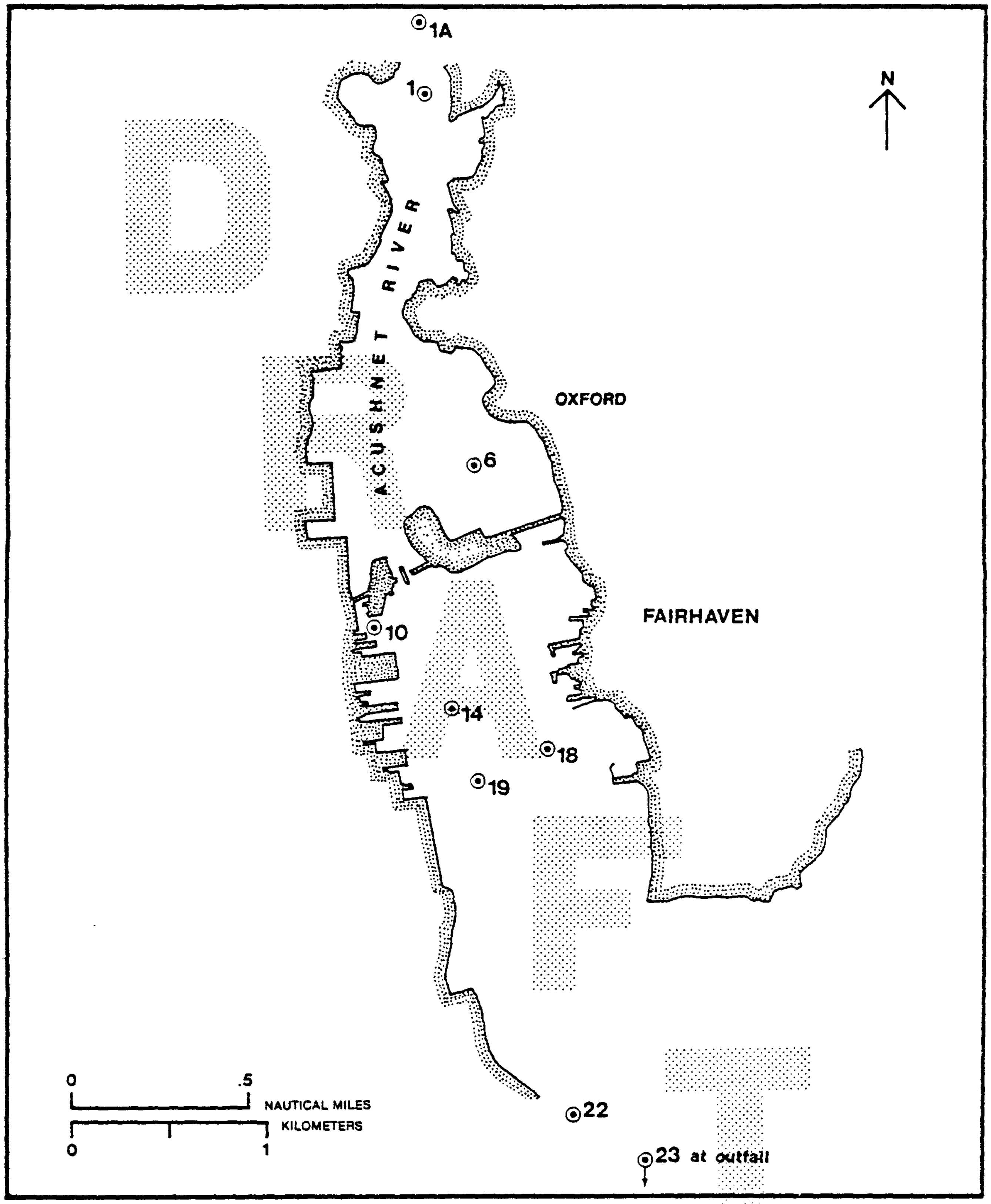

Figure 26. Location of selected PCB sediment stations sampled by the Massachusetts Department of Environmental Quality Engineering (New Bedford, MA).

outfall station (23) had one of the highest recent PCB-1254 concentrations in surficial [e.g., 0 to 10.2 cm (0 to 4 in) deep] sediments (Table 33). The data indicate the high levels of sediment PCB contamination throughout the inner harbor. Only a few sites were sampled outside of the hurricane barrier. Two of those sites are located in the ship channel and may not be reflective of recent contamination due to dredging activities. Thus, there is limited comparative basis within this data set to evaluate the level of contamination at the outfall. However, the data do indicate that the sediments near the existing outfall currently have a high level of PCB contamination. The PCB concentration reported by DEQE at the outfall site is also comparable to the PCB levels reported by the applicant for the CDM studies.

It should also be emphasized that the DEQE sediment analyses are only for PCB-1254. The PCB mixtures reported in the CDM studies are not specified. Such analyses may result in an underestimation of the magnitude of the PCB contamination by not analyzing for the lower molecular weight and less-substituted, PCB mixtures. In the applicant's effluent analyses, concentrations of PCB-1254 and PCB-1232 are reported at similar concentrations. Farrington and Sulanowski (1981) also report that mussels (Mytilus edulis) from New Bedford Harbor had similar concentrations of PCB-1242 or 1016 and PCB-1254 mixtures. Thus, future studies should analyze for all potential PCB mixtures, especially those identified in the applicant's effluent.

TABLE 33. SEDIMENT CONCENTRATIONS (mg/kg) OF PCB-1254 AT SITES SAMPLED BY THE MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

Station	Depth cm (in)	1979	1980
1	0-10.2 (0-4)	39.7	2.6
	10.2-20.3 (4-8)	25.9	10.0
1A	0-10.2 (0-4)	72.7	-
	10.2-20.3 (4-8)	-	118
6	0-10.2 (0-4)	43.1	4.7
	10.2-20.3 (4-8)	0.2	ND[b]
10	0-10.2 (0-4)	7.9	1.66
	10.2-20.3 (4-8)	3.2[a]	0.36
14	0-10.2 (0-4)	2.0	ND
	10.2-20.3 (4-8)	9.6	ND
18	0-10.2 (0-4)	-	1.25
	10.2-20.3 (4-8)	-	1.0
19	0-10.2 (0-4)	0.9	<0.01
	10.2-20.3 (4-8)	-	ND
22A	0-10.2 (0-4)	43.6	0.92
	10.2-20.3 (4-8)	-	-
23 (outfall)	0-10.2 (0-4)	-	15.6
	10.2-20.3 (4-8)	-	0.3

[a] 0-7.6 cm (0-3 in).

[b] ND, none detected.

Source: Personal communication (written response to phone request) on September 11, 1981, by Mr. M. Griben with Mr. Richard Packard, Massachusetts Department of Environmental Quality Engineering, Lakeville, Massachusetts.

Shellfish Tissue Analyses--The applicant presents a brief discussion of a study of bioaccumulation in shellfish in the New Bedford Harbor-Buzzards Bay area. The 10 stations sampled represented one site near the outfall (SF5); seven beyond ZID sites (SF2, SF3, SF4, SF6, SF19, SF16, SF17), one control site (SF15), and one site in the general vicinity of the proposed outfall (SF14). These sampling areas represent 10 of the 20 stations described previously in the Shellfish subsection. As such, they have the same limitations relative to the applicant's designation of station locations.

The applicant presents data for tissue concentrations of 12 metals, arsenic, and PCB. The analytical methods followed acceptable techniques. However, the applicant's description of other methods is inadequate, and this results in the data being of limited utility in making among-site comparisons of tissue concentrations. Notably lacking is a description of the species collected. The applicant states only that "At each station, ten (10) shellfish were taken to obtain a representative population." Due to potential differences in bioaccumulation among species, this represents a serious limitation of the studies. The stations sampled by the applicant had distinctly different shellfish assemblages and samples taken to approximate the species composition at each site could result in apparent differences in bioaccumulation that are actually due to differential uptake rates among species. Moreover, the applicant does not describe the tissue(s) analyzed for each species, and this could also introduce considerable bias in the data.

Evaluation of the shellfish collections at each station used for the bioaccumulation analyses indicates that comparisons among the existing outfall site (Station SF5), a beyond-ZID site (Station SF2), the proposed outfall site (Station SF14), and the putative control site (Station SF15), would be inappropriate if the applicant actually sampled a "representative population" at each site. For example, the samples as SF2 were composed of oysters and quahogs, while those at SF5 (outfall) were dominated by quahogs with a few false quahogs (application Table XI-24). False quahogs were dominant at SF14, and no quahogs and only a few false quahogs were collected at the "control" site, SF15.

The applicant also presents the results of tissue analyses of 136 toxic substances in shellfish tissue from Station S5, which the applicant refers to as the "ZID area." These studies are also poorly described, without specification of sample site, organisms collected, or tissue(s) analyzed.

Although the applicant's bioaccumulation data are of limited use in assessing effects of the existing outfall, they are presented in Table 34 for comparative purposes. Stations SF5, SF3, SF4, and SF16 had similar shellfish communities based on the relative densities of Mercenaria and Pitar collected at each station, and therefore can be used to make limited comparisons of tissue concentrations near the existing outfall with those of surrounding areas in New Bedford Harbor.

For some metals (chromium, copper, nickel, and zinc), the shellfish tissue concentrations near the existing outfall were higher than those in

TABLE 34. TISSUE CONCENTRATIONS (mg/wet kg) OF SELECTED METALS AND PCB IN SHELLFISH COLLECTED FROM NEW BEDFORD HARBOR AND BUZZARDS BAY

Station	Mercury	Cadmium	Chromium	Copper	Nickel	Zinc	Silver	PCB
SF5 (existing outfall)	<0.0119	0.205	3.25	1.85	4.35	11.5	0.10	<0.001
SF4	0.0774	0.25	2.95	0.33	2.85	6.35	<0.07	0.062
SF16	0.1015	0.25	3.65	0.44	2.20	4.50	0.12	0.407
SF3	<0.0119	0.23	2.20	1.10	0.80	6.60	0.39	0.068
SF2	<0.0119	0.040	1.27	0.23	0.21	1.15	0.09	1.000
SF14 (proposed outfall)	0.0548	0.180	1.75	0.51	0.76	2.65	<0.07	0.001
SF15 (control)	0.0246	0.52	2.85	1.25	1.35	13.5	0.17	0.003

Source: Application Table XVII-17.

the surrounding areas. The applicant also reaches this conclusion. Other toxic substances display no apparent elevation near the outfall. The lowest PCB concentration measured by the applicant was in the near-outfall sample.

The comprehensive analysis of toxic substances in samples collected near the existing outfall revealed that the only organic compounds measured above detection limits were butyl benzyl phthalate (0.004 mg/wet kg), pyrene (0.001 mg/wet kg), and PCB 1254 (< 0.001 mg/wet kg).

The low PCB concentrations reported by the applicant are considerably less than concentrations reported in other studies of New Bedford Harbor. A 1976 sample of quahog tissue collected in the vicinity of the existing outfall by the Massachusetts Division of Marine Fisheries had a PCB concentration of 1.3 mg/wet kg (as reported in application Table XVII-19). Kolek and Ceurvels (1981) report a PCB concentration of 1.8 mg/wet kg for a 1976 quahog sample from the existing outfall station. Other quahog samples collected in 1976 from the general vicinity (Stations 23 and 24 in application Figure XVII-7) had PCB concentrations of 0.41 to 0.44 mg/wet kg. Although these concentrations are considerably higher than concentrations reported for quahogs in the applicant's study, they are well below the FDA Action Level of 5 mg/wet kg.

Other marine and estuarine species in the New Bedford area have PCB concentrations which have resulted in the closure of the area to the taking of some commercial and recreational species (see Commercial and Recreational Fisheries subsection above). Highest tissue concentrations are reported from the Acushnet River and inner harbor, areas near the previous point sources of PCBs.

The applicant recognizes the PCB contamination in the area and provides a tabular review of various studies during the period of 1976-1978. A recent report by Kolek and Ceurvels (1981) provides a discussion of PCB contamination in New Bedford harbor as a function of species and area. Although considerable data is provided for the general area, it does not allow for an evaluation of the potential contribution of the New Bedford outfall to the high levels of PCB contamination in New Bedford harbor and Buzzards Bay. However, based on a review of the New Bedford 301(h) application, Kolek and Ceurvels (1981) conclude that "The presence of PCB's in the sewage effluent and sediment adjacent to the [New Bedford] outfall pipe indicate that this is also a source of contamination...." In an analysis of effluent samples conducted in 1979, the applicant reports effluent concentrations of 10 ug/l of PCB-1254 in wet-weather samples and 9.3 ug/l of PCB-1232 in dry-weather samples. Thus, in 1979, substantial amounts of PCBs were most likely being discharged in the New Bedford sewage effluent. These observations, in combination with the observed PCB sediment contamination near the outfall, suggest that the existing New Bedford sewage discharge may be contributing to the PCB contamination of fish and shellfish. It should be recognized, however, that the levels of sediment contamination by PCBs are much higher inside the hurricane barrier in New Bedford harbor than near the outfall, and that attributing observed contamination, especially in motile organisms, to individual sources is tenuous with available data. Following their evaluation of past PCB data, Kolek and Ceurvels (1981) also conclude that "Review of the data collected to date indicate [sic] that sampling results are insufficient to establish definitive PCB trends in the biota of New Bedford Harbor."

Section 7. Biological Assessment Questionnaire

The applicant responds to Questions 7-1 through 7-11 and to Question 7-13 of the Biological Assessment Questionnaire. Each one-word response is followed by a brief supportive summary statement. The responses to Questions 7-1 through 7-11 pertain primarily to the existing outfall. Predictive responses for the proposed improved outfall are addressed by the applicant in the response to Question 7-13. Question 7-12 is not answered because the applicant considers the receiving waters in the vicinity of the proposed outfall to be unstressed.

Question 7-1. *Has the discharge interfered with a balanced indigenous population of marine life?*--

The applicant supplies a positive response to Question 7-1.

Phytoplankton--The applicant contends that the phytoplankton sampling program demonstrated that this community "exhibited no distributional changes which could be attributed to the outfall." In reality, phytoplankton sampling conducted in support of the application is insufficient for making the required BIP comparisons for the following reasons:

1. Collection of phytoplankton at only two stations in the vicinity of the outfall may not be adequate for a definitive evaluation of potential impacts of the effluent discharge on

phytoplankton, since such effects may not be manifested in the immediate vicinity of the outfall.

2. Characterization of a BIP of phytoplankton for this area was inadequate due to lack of information on seasonal variability, omission of measurements of primary productivity and/or community biomass, and failure to identify the majority of phytoplankton to species.

3. The lack of replicate samples at each station precluded an evaluation of the significance of observed differences between stations in cell densities and/or numbers of taxa.

Although the applicant asserts that:

> "There were no major qualitative differences among Stations P1 and P2 (in and immediately beyond the ZID), Stations P7, P8, and P9, and Station P17 (reference) indicated by Jaccard's coefficients,"

it should be noted that Stations P1 and P2 had only 41 to 57 percent of their phytoplankton taxa in common with the other stations. This low qualitative similarity is suggestive of inadequate sampling at each station, especially when stations as close together as Stations P1 and P2 had only 50 percent of their phytoplankton taxa in common. The applicant's assertion that "no major qualitative differences" existed cannot be substantiated.

Although the applicant's calculation of chi-square values could not be verified as part of this evaluation, the applicant states that they indicated significant differences among the stations in "the unit abundance of major phytoplankton groups." The applicant does not give any interpretation for the fact that all stations tested had significantly different phytoplankton assemblages.

With regard to cell densities, the applicant asserts that:

> "There were no large density differences among the major phytoplankton groups at any of the stations that could not be explained as natural variability in the phytoplankton community."

Examination of the applicant's Table XI-16 would seem to corroborate this assertion, although it should be noted that replicate samples and rigorous statistical analyses would be required to estimate the statistical significance of any observed differences in the abundances of major phytoplankton groups. The possibility also exists that large differences occurred between stations in the abundances of individual taxa. Since these abundances are not reported, this possibility cannot be explored.

Higher total phytoplankton densities in the vicinity of the ZID may only represent a typical onshore-offshore gradient in phytoplankton abundance. The total phytoplankton density reported for the outfall station is similar to the density of phytoplankton cells in lower Narragansett Bay in late summer (Smayda 1958), suggesting that this is not an abnormally high density. Once again, replicate samples and rigorous statistical analyses would be required to estimate the statistical significance of any observed differences in total phytoplankton abundance.

In summary, the phytoplankton data collected in 1979 revealed dramatic differences in community composition and minor differences in overall abundance, both between two stations in the immediate vicinity of the existing outfall ZID and between these stations and four other stations, including a reference station in Nasketucket Bay and a station near the site of the proposed outfall. Certainly, more extensive sampling would be required to determine whether these observed trends are statistically significant and whether they occur at other times throughout the year. With the data currently available, it cannot be determined whether the existing effluent discharge has interfered with the protection and propagation of a BIP of phytoplankton.

Zooplankton--It is the applicant's contention that the zooplankton sampling program demonstrated that this community "exhibited no distributional changes which could be attributed to the outfall." In reality, this sampling program was insufficient for making the required BIP comparisons for the following reasons:

1. There has been no attempt to accurately define a BIP of zooplankton characteristic of this biogeographic zone.

Particularly lacking are estimates of both within-station and seasonal variability.

2. The lack of replicate samples precludes statistical analysis of differences in abundance between stations, either for individual taxa or for the zooplankton community as a whole.

3. Failure to note the tidal stage at the time of sampling opens the question of whether or not the beyond-ZID sample could be expected to show effects of the effluent discharge. This omission also renders the comparison of the outfall stations with the control stations in Nasketucket Bay of dubious significance, since, depending upon the tidal stage, the control stations may have been more influenced by inshore or offshore waters than the corresponding stations in the vicinity of the existing and proposed outfalls.

Due to the extremely limited zooplankton sampling program (one sample at each of six stations), the applicant's conclusions should be regarded as very tenuous. In the absence of information on within-station and/or seasonal variability, statements in Appendix XI of the application that "Diversity values within this range indicated a fairly diverse community" and that the "spread of values was not great enough to indicate an appreciable difference among the stations" cannot be taken as conclusive evidence that the existing effluent discharge has not adversely affected the zooplankton communities.

Comparison of the applicant's zooplankton data with data on copepod abundances in Buzzards Bay (Anraku 1964) and on zooplankton in Narragansett Bay (Jeffries 1964) suggested to the applicant that the zooplankton samples collected in New Bedford Harbor "indicate a typical coastal marine environment." While this conclusion appears valid, certainly a more comprehensive sampling program would be necessary to state definitively that the existing discharge has not adversely affected the zooplankton communities.

Benthic Infauna--The applicant states that:

> "All benthic community parameters indicated changes in the outfall area. The effect was found to extend at least 25 m from the outfall. A location 640 m distant was not affected. It was concluded the zone of degradation for the benthic community was less than 640 m from the outfall."

The conclusion reached in this evaluation is that the data provided in the application are inadequate to definitively demonstrate that the existing discharge has not and will not interefere with the protection and propagation of a benthic BIP. Potential limitations of the applicant's benthic studies include: a) the possible lack of a sampling station within the ZID, b) the small sample size used for enumeration of benthic species, c) the lack of an assessment of seasonal variation, and d) the use of questionable data reduction techniques prior to application of cluster analysis.

Despite these limitations, several tentative conclusions were drawn in this review, based on the applicant's study:

1. The species richness, faunal density, and diversity of benthic infaunal communities at Stations B1 and B2 in the vicinity of the existing discharge generally are lower than values of those parameters at other inshore stations farther away from the discharge and at possible reference sites in Nasketucket Bay (Stations B17 and B18).

2. The existing discharge appears to cause a major reorganization of benthic community structure near the outfall [i.e., within about 167 m (548 ft) from the outfall according to station coordinates given by the applicant]. This reorganization may reflect the existence of a community which has passed the "peak of opportunists" defined by Pearson and Rosenberg (1978).

3. The existing discharge does not appear to cause major changes in benthic infaunal communities beyond the ZID at distances greater than and equal to about 600 m (2,000 ft) from the outfall.

The applicant's interpretations of the benthic data generally parallel those expressed in this evaluation. However, it is important to note that the applicant has not explicitly defined a BIP of benthic infauna for the existing outfall area. The clustering of Stations B17-B20 in Nasketucket Bay with "offshore" Stations B3, B7, B8, B9, and B15 in Buzzards Bay is taken by the applicant to indicate a "normal biological community" at Stations B15 [about 600 m (2,000 ft) from the outfall] and at other sites farther from the outfall. The applicant initially designates Station B17 as a control station for the existing discharge. However, the applicant performs statistical comparisons of Stations B1 and B2 'near" the existing outfall with the inshore group (Stations B4, B6, B11, B12, B13, and B14) in lieu of pair-wise statistical comparison of Stations B1 and B2 with the putative control Station B17. Thus, it is unclear whether the applicant considers benthic fauna at the inshore sites or at Station B17 to represent a BIP for the existing outfall location. It was concluded in this review that data included in the application are insufficient to document the existence of control conditions at any of the sites where sampling was conducted.

<u>Rocky Intertidal</u>--In response to this question, the applicant states that: "Studies conducted on...intertidal communities exhibited no distributional changes which could be attributed to the outfall."

It was concluded earlier in this evaluation that the studies cited are inadequate for an assessment of impacts on intertidal communities potentially caused by the existing and proposed discharges. The intertidal studies did not adequately define an intertidal BIP because of limited identification of species. The applicant failed to provide details of procedures used to sample intertidal fauna, so that the reliability and accuracy of the results are difficult to evaluate. The sampling procedures used by the applicant to determine percent algal cover were inadequate for accurate estimation of mean percent cover even for the most abundant macroalga, Fucus vesiculosus.

Fishes--The applicant responds that the fish survey indicated "no distributional changes which could be attributed to the [existing] outfall." This is not a reasonable conclusion based upon the limited fish survey conducted by the applicant. The 1-day survey in August, 1979, cannot be employed to elucidate in detail the spatial and temporal distributions of the major indigenous fish species occurring in New Bedford Harbor. The applicant states that "Based on the limited fish data no conclusions can be drawn in regard to species at the various stations." Therefore, the available information is insufficient to conclude that the existing discharge has not adversely impacted the New Bedford Harbor fish fauna. However, the species which were collected during the survey are representative of the indigenous southern Massachusetts coastal fish fauna during August.

The applicant predicts that the relocated outfall with improved effluent treatment will have a minimal impact on fishes. However, the applicant did not provide sufficient information to permit an evaluation of the indigenous fish community at the proposed outfall. Trawl Station F14 was considered by the applicant to be in the vicinity of the proposed outfall; however, it appears to be located approximately 1.2 km (0.8 nmi) northwest of the proposed site. Furthermore, the wide depth zone sampled at F14 and the absence of information on the substrate at the proposed site precludes a determination that fishes collected at F14 are representative of the community occurring at the proposed outfall. Therefore, without additional information regarding fishes at the proposed outfall location, an evaluation of potential discharge impacts cannot be reasonably made.

Shellfish--The applicant responds that the shellfish dredge survey indicated "no distributional changes which could be attributed to the [existing] outfall." This is not a reasonable conclusion based upon the limited shellfish survey conducted by the applicant. This survey cannot be employed to elucidate in detail the spatial and temporal distributions of the major indigenous shellfish species in New Bedford Harbor. The applicant states that "Results from the dredge are inconclusive with regard to effects of the [existing] outfall on the quahog [Mercenaria] population." The major drawback of the shellfish survey was unequal sampling effort at the various stations. It is unclear whether stations where large numbers of individuals were collected represent areas of high density or whether the large catches there are simply an artifact of extended dredging time.

The applicant could not demonstrate that the shellfish community at a station, SF5, in the vicinity of the existing discharge was similar to the one encountered at the designated control site, SF11. For stations located beyond the existing ZID (SF4, SF20) and in the vicinity of the proposed outfall (SF14) and control (SF15), little similarity was noted. The shellfish data collected by the applicant are inadequate to reasonably *evaluate the impact of the existing or proposed discharges on the indigenous* shellfish community of New Bedford Harbor. However, the species which were collected are typical of those expected in New England coastal waters.

Question 7-2. Do biological communities within the ZID differ from those that would occur in the absence of the outfall?--

The applicant *supplies a positive response to Question 7-2.*

<u>Phytoplankton</u>--The applicant's statement that the phytoplankton community "exhibited no distributional changes which could be attributed to the outfall" presumably implies that the applicant contends that phytoplankton within the ZID of the existing outfall are not different from those that would naturally occur in the absence of the outfall. Two phytoplankton samples were collected in the immediate vicinity of the existing ZID. The applicant describes Station P1 as being "within the ZID" and Station P2 as being "immediately beyond the ZID." As discussed in greater detail in Part B, Section 6 of this evaluation, there is some uncertainty regarding the exact relationship of these stations to the position of the existing outfall; according to station coordinates given in Table XI-1 of the application, Station P2 is actually closer to the outfall than is Station P1 [76 m (249 ft) vs. 167 m (548 ft)]. This apparent discrepancy cannot be resolved with the information available in the application; it is, however, of relatively little consequence since phytoplankton are carried about by movements of the water and are not permanent residents of any given location.

The two stations in the vicinity of the existing outfall had only 41 to 57 percent of their phytoplankton taxa in common with the four other stations sampled. The applicant also reported significant differences "in the unit abundance of major phytoplankton groups" between these stations and the other stations sampled by the applicant. While both conclusions were questioned because of possible inadequate sampling and inappropriate statistical analysis (see Part B, Section 6, Phytoplankton above), they do suggest possible outfall-related effects which could be explored in greater detail if a more rigorous sampling program were conducted.

The applicant notes that members of the Euglenophyta and Cyanophyta (two groups which sometimes attain high densities in eutrophic systems) were present near the existing outfall (Stations P1 and P2) and at Station P7. Members of the Cyanophyta were also present at Stations P8 and P9, however, and both groups were in low abundance at all stations where they were present. Since they were not present in high abundance near the outfall, severe eutrophication is not suggested.

Judging from the limited data available, the total phytoplankton density in the immediate vicinity of the existing outfall did not appear to be unreasonably high. This and all other conclusions regarding phytoplankton populations in the area around the existing outfall must remain extremely tenuous until a more definitive phytoplankton sampling program is conducted.

<u>Zooplankton</u>--The applicant's statement that the zooplankton community "exhibited no distributional changes which could be attributed to the outfall" presumably implies that the applicant contends that zooplankton within the ZID of the existing outfall are not different from those that would naturally occur in the absence of the outfall. The applicant collected only a single zooplankton sample in the immediate vicinity of the existing ZID, and it is not clear whether the net was towed within or immediately outside the ZID. Actually, this is of little consequence since zooplankton are carried about by movements of the water and hence are not permanent residents of a given area.

While the Shannon-Wiener diversity of the zooplankton collected near the existing outfall was slightly higher than that of the sample collected at the corresponding control site (2.89 vs. 2.80), the zooplankton communities were markedly different, as evidenced by the separation of the existing outfall sample from all five other samples in the applicant's cluster diagram (Figure XI-8 of the application). Although the generation of this dendrogram could not be verified as part of this evaluation (see Part B, Section 6 above), it seems likely that the uniqueness of the existing outfall sample was due to the abundance of larval barnacles and gastropods there, as suggested by the applicant. While it is doubtful that an increased abundance of these forms would be related to the effluent discharge, it does open the question of the comparability of the outfall and "control" stations, where the abundance of these forms was considerably lower. The lack of replicate samples at each station precludes testing the significance of any observed differences in abundance, however. Certainly a more comprehensive sampling program would be necessary to state definitively that the existing discharge has not altered zooplankton communities in the vicinity of the outfall.

Benthic Infauna--The applicant indicates that "Species richness, faunal density, and diversity for benthos were depressed...at stations within and immediately beyond the ZID." As discussed earlier in this evaluation, it is unclear whether or not the applicant sampled benthic infauna within the ZID. The sampling sites nearest the existing outfall. Stations B1 and B2, are located about 158 m (518 ft) and 67 m (220 ft) beyond the ZID boundary, according to calculations performed as part of this evaluation.

It was concluded as part of this evaluation that species richness, faunal density, and diversity of benthic infauna appeared to be depressed at Stations B1 and B2 relative to communities at stations farther away from the existing outfall. Limitations of the applicant's sampling procedures and study design preclude a definitive assessment of impacts within the ZID.

The applicant's positive response to Question 7-2 seems appropriate even if Stations B1 and B2 were beyond the ZID. In most instances, impacts on benthic infaunal communities caused by a sewage discharge are expected to be greater within the ZID than beyond the ZID.

Rocky Intertidal--There are no intertidal habitats within the ZID of either the existing discharge or the proposed discharge. Thus, Question 7-2 does not apply to intertidal communities.

Fishes--The applicant again responds that the fish survey indicated "no distributional changes which could be attributed to the [existing] outfall." This is not a reasonable conclusion based upon the limited fish survey conducted by the applicant. Trawl Station F5 apparently included the area within and immediately beyond the ZID of the existing discharge. A large number of fish, consisting of only a single species, the scup, was collected at this station during the August, 1979, survey. The applicant does not suggest an explanation for the large concentration of scup at this site. It is possible that the trawl by chance sampled a school of scup traveling through the existing discharge area. Another possibility is that the fish are attracted to the existing outfall to feed on discharged particulate matter or on benthic prey items. Additional investigation is required to determine if scup or other fish species are attracted to the outfall. Therefore, it is not possible to conclude that the existing discharge has not altered the fish community within the ZID.

The applicant predicts that fish will not be severely impacted within the ZID of the proposed discharge. As indicated under Question 7-1, sufficient data are not available to characterize the fish community at the proposed outfall. If fish are being attracted to the existing discharge, a similar situation may occur at the proposed site. Therefore, additional data are required to adequately evaluate the potential impacts of the proposed outfall on the indigenous fish community.

Shellfish--The applicant again responds that the shellfish survey indicated "no distributional changes which could be attributed to the [existing] outfall." This is not a reasonable conclusion based upon the limited shellfish survey conducted by the applicant. Station SF5 apparently included the area within and immediately beyond the ZID of the existing discharge. The substrate in the vicinity of SF5 is not homogeneous. Because the shellfish dredge was probably dragged over a considerable distance, organisms preferring specific sediment types may have been combined in the SF5 sample. Therefore, it is difficult to determine if differences exist between shellfish assemblages within and immediately beyond the ZID. It is not possible to conclude that the existing discharge has not altered the shellfish community within the ZID.

The applicant predicts that the relocated outfall will have a minimal impact on shellfish within the ZID. As indicated under Question 7-1, sufficient data are not available to characterize the shellfish community within the ZID of the proposed outfall. In the cluster analysis, little similarity was noted between Station SF14, in the vicinity of the proposed outfall, and Station SF15, the reference site in Nasketucket Bay. Without further information on the nature of the shellfish community within the proposed outfall ZID, no conclusions may be made regarding potential impacts.

Question 7-3. Are there differences between biological communities beyond the ZID and in control areas?--

The applicant supplies a positive response to Question 7-3.

Phytoplankton--The applicant indicates that no impacts of the existing effluent discharge on phytoplankton were detected. With regard to an assessment of possible differences in the structure and function of phytoplankton communities beyond the ZID, it is important to note the locations of the stations sampled by the applicant (Figure 20). As indicated above (Part B, Section 6, Phytoplankton, as well as in response to Question 7-2), both Stations P1 and P2 appear to be beyond the ZID [167 m (548 ft) and 76 m (249 ft) from the outfall respectively, or 158 m (518 ft) and 67 m (220 ft) beyond the ZID, respectively]. The next closest station (P7) is located approximately 2.7 km (1.65 mi) offshore from the existing outfall, and therefore might be considered to be a beyond-ZID station. It is not indicated whether this station was in the direction of current flow at the time of sampling, however, and it may have been too far away from the outfall to detect an effluent-related effect on phytoplankton. Ideally, it would have been more apropriate to have other phytoplankton stations in the direction of current flow at intermediate distances from the outfall, because phytoplankton are carried about by movements of the water and there may be a lag time in the response of phytoplankton to effluent inputs.

Aspects of the detection of possible outfall-related effects on the structure of phytoplankton communities were discussed in response to

Question 7-1 above. It was concluded that a more rigorous phytoplankton study would have to be conducted before it could be determined whether the effluent discharge had caused alterations in this community.

Functional aspects of the phytoplankton community were not studied. Notably lacking are measurements of primary production of the phytoplankton, which might be expected to be affected by the discharge of sewage effluent. Either enhancement or inhibition of primary production may occur, since sewage effluent represents both a significant source of nutrients and a possible source of inhibitory substances. In the absence of direct measurements of primary production, estimates of phytoplankton abundance (cell counts or chlorophyll _a_ measurements) could be used for an examination of possible enhancement. While cell densities in the area of the outfall were not unreasonably high, the possibility exists that enhancement may occur at greater distances from the outfall, or that it may occur during other times of the year, since the applicant conducted sampling over only a 3-day period. Inhibition of primary production cannot be detected by examining data on phytoplankton abundance; in the absence of direct measurements of primary production, nothing is known about possible inhibitory effects of the New Bedford effluent discharge.

Zooplankton--The applicant indicates that no impacts of the existing effluent discharge on zooplankton were detected. As discussed in detail in the evaluation of Part B, Section 6, and in the responses to Questions 7-1 and 7-2 above, the extremely limited nature of the zooplankton sampling program renders the applicant's conclusions very tenuous. With regard to differences in the structure and function of zooplankton communities beyond the ZID, the paucity of sampling locations beyond the ZID and the failure to note the state of the tide at the time of sampling make it difficult to determine whether such differences actually occur. Sampling would have to be conducted at a greater number of stations beyond the ZID and at different tidal stages in order to determine whether the existing discharge has adverse effects on the structure and function of the zooplankton community beyond the ZID.

Benthic Infauna--In response to this question, the applicant states that:

> "Impacts of the applicant's outfall on the benthic community were found to extend at least 25 m from the outfall location. The 25 m station was impacted and the limit of the impacted zone was less than 640 m from the outfall."

The applicant's assessment of discharge-induced impacts on benthic infauna beyond the ZID appears reasonable. As noted in the evaluation of Question 7-1 above, however, the applicant has not clearly defined a BIP of benthic infauna for the existing discharge area. Based on the results of the applicant's benthic surveys, it appears that the existing discharge causes alterations of the structure of benthic infaunal communities beyond the ZID relative to the structure of a BIP characteristic of this biogeographic zone. Without verification of the applicant's results by a more intensive survey, this conclusion must remain tentative.

Rocky Intertidal--Although the applicant recognizes impacts on benthic macrofauna caused by the existing discharge, the applicant indicates that "no other impacts on the other communities were detected in the distributional studies." As discussed earlier in the evaluation of Question 7-1, the studies of intertidal assemblages were inadequate for assessment of the potential effects of the discharge.

Fishes--The applicant states that, as indicated in the responses to Questions 7-1 and 7-2, "no other impacts [other than on benthos] on other communities were detected in the distributional studies." This is not a reasonable conclusion based upon the limited fish data provided by the applicant. Trawl Station F5 apparently included the area within and immediately beyond the ZID of the existing discharge. Therefore, because fish from both areas were sampled together, it is not possible to determine if the fish community immediately beyond the ZID has been impacted by the existing discharge. As indicated under Question 7-2, a large number of scup was collected at F5. The applicant does not suggest an explanation for this large collection of fish. It is possible that by chance the trawl collected a school of scup passing through the existing discharge area, or that the species was actually attracted to the existing outfall site. Further studies are required to document fish attraction to the existing outfall.

The applicant predicts that no adverse impacts on the fish community beyond the ZID of the proposed outfall will occur. The data provided by the applicant are not sufficient to substantiate this conclusion. If fish attraction is occurring at the existing site, a similar situation may develop at the proposed outfall. Therefore, additional studies are required to adequately evaluate potential impacts of the proposed discharge on the fish community beyond the proposed ZID.

Shellfish--The applicant states that, as indicated in the responses to Questions 7-1 and 7-2, "no other impacts [other than on benthos] on other communities were detected in the distributional studies." This is not a reasonable conclusion based upon the limited shellfish data provided by the applicant. Station SF5 included the area within and immediately beyond the ZID of the existing discharge. Therefore, because shellfish from both areas were sampled together, it is not possible to determine if the shellfish community immediately beyond the ZID has been impacted by the existing discharge.

The cluster analysis indicated that the existing outfall Station SF5 and one beyond-ZID site, SF4, were similar. However, this resemblance appears to be based only upon the abundance of Mercenaria at both sites. Station SF20, also located beyond the existing ZID, did not cluster with the former sites, probably due to its lower abundance of Mercenaria. Sampling effort may have varied among these stations, and therefore the species abundances may be biased. Further data are required to determine if the existing outfall has impacted shellfish beyond the ZID.

The applicant predicts that no adverse impacts on the shellfish community beyond the ZID of the proposed outfall will occur. As previously indicated, the applicant did not adequately characterize the nature of the shellfish community in the vicinity of the proposed outfall. Therefore, additional data are required to evaluate potential impacts on the shellfish community beyond the proposed outfall ZID.

Question 7-4. Has the discharge caused increases in abundance of marine plants or animals not characteristic of the area?--

The applicant supplies a negative response to Question 7-3.

Phytoplankton--The applicant responds that "No increased populations of nuisance or toxic species were encountered in this study." Among the marine phytoplankton, species commonly believed to be nuisance species are generally dinoflagellate species associated with red tides. The applicant notes that species of Gymnodinium and other dinoflagellate genera were found at all stations, but that they were always present in low densities and no toxic species were identified. In New England, red tides which have caused paralytic shellfish poisoning (PSP) are associated with blooms of Gonyaulax tamarensis, but the applicant does not list Gonyaulax among the dinoflagellate genera identified during the CDM phytoplankton study. Its absence from the area during the limited duration of the phytoplankton study does not mean that it never occurs in the area, however. Red tides have never been reported from the New Bedford area, and the closest they have occurred to New Bedford is in the Falmouth area, approximately 24 km (15 mi) from New Bedford on the opposite side of Buzzards Bay[a]. The extent to which the discharge of sewage effluents in the New Bedford area will enhance the growth of red-tide organisms in the future is unknown.

Benthic Infauna--The applicant does not discuss the possibility that the discharge causes increases in the abundance of any benthic species not characteristic of the biogeographic zone in which the outfall is located. Despite the limitations of the data on which the applicant's assessment is based, the infaunal species which appear to dominate the area "near" the outfall (Stations B1 and B2) are characteristic of the biogeographic zone, and are not considered to be nuisance species.

Rocky Intertidal--The applicant states that "No increased populations *of nuisance or toxic species were encountered in this study....*" Based on data provided by the applicant, *Balanus balanoides* and *Fucus vesiculosus* appeared to be the dominant faunal and floral species, respectively, in intertidal communities at Station I1 located directly inshore from the existing discharge. These species are not considered to be nuisance or toxic species.

Fishes--During the fish survey conducted by the applicant a large catch of scup was collected at Station F5, apparently located within and

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[a] Personal communication (phone) on September 14, 1981, by Dr. Lawrence E. McCrone, with Mr. Richard Packard, Mass. Dept. Environmental Quality Engineering, New Bedford, Massachusetts.

immediately beyond the ZID of the existing discharge. It remains to be determined whether the concentration of scup was a chance occurrence or if this species is attracted to the existing outfall. Scup are characteristic of the biogeographic zone in which the existing outfall is located and are also known to display highly localized distributions. It is unlikely that the proposed outfall will cause an increase of fish species which are not characteristic of southern Massachusetts coastal waters.

Shellfish--The data provided by the applicant do not indicate the presence of uncharacteristic shellfish species within or beyond the ZID of the existing discharge. The dominant species collected at the existing discharge station, SF5, was Mercenaria, an economically important shellfish.

Question 7-5. Have pollution-resistant species become dominant?--

The applicant supplies a positive response to Question 7-5.

Benthic Infauna--The applicant states that:

> "Benthic communities within the ZID and immediately beyond the ZID (25 m) were dominated by the opportunistic polychaetes Capitella capitata and Nereis succinea, respectively."

As discussed earlier in this evaluation, the applicant may not have sampled benthic infauna within the ZID of the existing discharge. It is apparent from the applicant's discussion in Appendix XI that "within the

ZID" refers to Station B1. Thus, it is assumed herein that the applicant's statement quoted above implies that the infaunal community at Station B1 is dominated by _Capitella capitata_, a species often indicative of organic pollution (cf. Pearson and Rosenberg 1978). The data presented by the applicant do not support the assertion that _C. capitata_ is dominant within the ZID. During the May, 1979, survey, _C. capitata_ was collected at Station B1, but it was not a dominant species in the samples. The abundance of _C. capitata_ at Station B1 during the August, 1979, survey is not referred to by the applicant. _C. capitata_ was excluded from the cluster and nodal analysis because it occurred in less than 10 percent of the total number of samples taken during the survey. However, exclusion does not imply that _Capitella capitata_ was not abundant at one or more stations, including Station B1. _C. capitata_ could have been dominant at Station B1 during the August survey, while occurring in less than 10 percent of all samples.

The applicant's statement that _Nereis succinea_ is dominant beyond the ZID is presumably based on nodal analysis, which showed coincidence of _Nereis_ sp. with Station B2 (Figure XI-6 of the application). [Limitations of the nodal analysis performed by the applicant were discussed earlier in this evaluation (Part B, Section 6, Benthic Infauna, Statistical Analysis).] Moreover, _Nereis_ sp. occurred in only one of three replicate samples taken at Station B2. Again, the applicant does not provide data on the absolute or relative abundances of each species at each station sampled during August, 1979. Without such data, the applicant's conclusion that _Nereis succinea_ is dominant immediately beyond the ZID is unsubstantiated.

It seems unlikely that the existing discharge would be responsible for domination of communities within or immediately beyond the ZID by N. succinea. Although N. succinea was found at Stations B1 and B2, it was also found at several sites farther away from the discharge, including Station 20 in Nasketucket Bay. Communities at Station 20 are probably not affected by the existing discharge.

The applicant does not address the occurrence of other infaunal species indicative of organic enrichment, which were collected during the August, 1979, survey. Streblospio benedicti [a polychaete species often associated with organic enrichment (Pearson and Rosenberg 1978)] was found at Station B1 and at several other stations (B6, B10, and B12) beyond the ZID. Other studies performed during November, 1975, suggest that Capitellidae are sometimes overwhelmingly dominant in benthic infaunal communities off the New Bedford coast [Kelly (1978), in Table XI-8 of the application]. According to the applicant's May, 1979, results, Mediomastus ambiseta is dominant in some areas beyond the ZID of the existing discharge. M. ambiseta may be indicative of moderate organic pollution (Pearson and Rosenberg 1978). Based on the available information, it is not possible to definitely determine if the existing discharge causes domination of benthic infaunal communities within or beyond the ZID by Streblospio benedicti or Mediomastus ambiseta.

Rocky Intertidal--Although the applicant recognizes the occurrence of opportunistic benthic species near the outfall, the applicant states that "No other dense populations of pollution resistant species from any of the communities studied were encountered." It was concluded earlier that the applicant's intertidal studies are inadequate for assessing impacts of the existing discharge. Nevertheless, these studies suggested that Balanus balanoides and Fucus vesiculosus are the dominant faunal and floral species, respectively, at a sampling location (Station I1) directly inshore from the existing outfall. These species are not considered to be pollution-resistant species.

Question 7-6. Has the discharge adversely affected any distinctive habitats of limited distribution?--

The applicant supplies a negative response to Question 7-6.

Fishes--The applicant does not indicate the location of important spawning, breeding, or foraging areas for the major indigenous fish species in New Bedford Harbor. It is likely that such areas do exist within the harbor; however, no information is available on these locations. The applicant does not present the weight and length data for the fish species which were collected. Therefore, it is not possible to ascertain whether juvenile or adult fishes utilize the harbor area.

The applicant did indicate that spawning alewives annually ascend the Acushnet River by way of New Bedford Harbor.

Without additional information, it is not possible to determine the impact of the existing or proposed discharges on important fish habitat areas.

Shellfish--It seems likely that the existing discharge has adversely impacted economically important shellfish beds within New Bedford Harbor. The discharge has probably contributed to coliform bacteria and PCB contamination in shellfish; however, the relative contributions of this and other pollutant sources remain to be quantified. As a result of this contamination, most shellfish beds in New Bedford Harbor are closed to both commercial and recreational fisheries.

With improved treatment, the coliform bacteria levels at the proposed outfall should be reduced and this may minimize the possibility of contamination. However, low levels of PCB in the effluent of the proposed discharge could cause shellfish to become contaminated at the site, and thereby prevent exploitation of the resource.

Question 7-7. Has an increased incidence of disease in marine organisms been noted?--

The applicant supplies a negative response to Question 7-7.

No evidence of fish disease was apparent on any of the 1,429 fish collected by the applicant during August, 1979. Fish disease has not been previously recorded in New Bedford harbor[a]. Based on these data, the

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[a] Personal communication (phone) on September 8, 1981, by Mr. M. Griben with Andrew Kolek, Massachusetts Division of Marine Fisheries, Sandwich, MA.

existing outfall does not appear to be a disease epicenter for fish within New Bedford Harbor. It is reasonable to assume that with improved treatment and relocation of the outfall that fish disease will not increase.

No information is available regarding disease of other organisms in New Bedford Harbor.

Question 7-8. Is there evidence of an abnormal body burden of toxic material in marine organisms?--

The applicant supplies a positive response to Question 7-8.

The applicant acknowledges that "Analyses conducted on shellfish tissue for trace metals and organics show that bioaccumulation is occurring." Although the applicant's studies indicated that several metals (e.g., Cr, Cu, Ni, Zn) occurred at higher concentrations in shellfish samples near the outfall when compared with surrounding areas, the studies were so superficially described that the results cannot be relied upon to provide a definitive demonstration of increased bioaccumulation at the existing outfall. Notably lacking are descriptions of tissues analyzed and species collected at each station. If it is assumed that such parameters were consistent among stations, then the data do suggest bioaccumulation near the existing New Bedford outfall. The potential for bioaccumulation near the outfall is also indicated by the CDM sediment survey. Elevated sediment concentrations of several metals and PCBs were detected at two stations near the outfall.

The applicant recognizes that high levels of PCB contamination occur in fish and shellfish in the New Bedford area. The PCB contamination has resulted in closures of several areas to the harvesting of some fish and shellfish (see description in Part B, Section 6, Commercial and Recreational Fisheries). The applicant's data indicated very low PCB concentrations ($\leq$ 0.001 mg/wet kg) in shellfish (species and tissue unspecified) collected near the existing and proposed discharges.

The results of the applicant's PCB analyses are contradictory, however, to other data from the area, which indicate elevated PCB concentrations in several marine organisms throughout New Bedford Harbor, including the vicinity of the existing outfall.

No tissue samples from the immediate vicinity of the existing outfall have had PCB concentrations exceeding the FDA action level of 5 mg/wet kg. This may be due to a lack of sampling effort at the outfall station [e.g., Kolek and Ceurvels (1981) present data for only one quahog sample from the outfall station]. Quahogs also contained relatively low PCB levels when compared with other organisms. Lobster, American eel, soft-shelled clam, and flounders were not collected for PCB analysis near the existing outfall, but the organisms had relatively high PCB levels (including many exceeding the FDA action level) throughout the area.

Question 7-9. Have there been any adverse effects on commercial fishes?--

The applicant supplies a positive response to Question 7-9.

The applicant contends that "the outfall contributed, but is not the sole source of adverse effects on the commercial and recreational fisheries within or beyond the zone of initial dilution."

The applicant presents a very limited description of commercial and recreational fisheries in New Bedford Harbor. No discussion is provided on the magnitude of the fisheries or the productivity of important fish stocks. The spatial distributions of the fishery species within the harbor are not described by the applicant, nor are spawning areas of the species identified.

Pollution has adversely impacted the fishery resources of New Bedford Harbor. The existing discharge has likely contributed to the high levels of coliform bacteria within the harbor, which resulted in the closure of shellfish beds.

PCB contamination has resulted in the closure of large areas of New Bedford Harbor to commercial and recreational fisheries for shellfish, crustaceans, and bottom-feeding fish. The applicant indicates that currently only trace levels of PCBs occur in the effluent of the existing discharge.

The applicant predicts that, while trace amounts of PCBs may be discharged at the proposed site, no adverse impacts on fish or shellfish should occur. No data were provided to substantiate this conclusion.

According to the applicant, improved treatment at the proposed outfall should reduce the high levels of coliform bacteria, and therefore not adversely impact shellfish. This is a reasonable assumption.

In conclusion, contamination of the available fishery resources by PCBs and coliform bacteria limit fishing opportunities in New Bedford Harbor. The existing outfall has likely contributed to harbor pollution; however, the extent of the discharge's contribution remains to be quantified. With improved treatment of the effluent discharged through the proposed outfall, coliform bacteria levels should be reduced. However, the trace amounts of PCBs in the current discharge are likely to be present in the effluent discharged at the proposed outfall site. The effect of low-level PCB contamination on fishery resources warrants further investigation prior to concluding that no adverse effects will occur.

Question 7-10. *Has there been any record of mass mortality of fishes or invertebrates in the area?--*

The applicant supplies a negative response to Question 7-10.

The applicant states: "No mass mortalities of finfish or invertebrates have been reported from the area or were detected during the current study."

However, mass mortalities of menhaden have occured inside the hurricane barrier of inner New Bedford Harbor during 1976, 1977, and 1978[a]. Such kills were reported in several Massachusetts coastal areas, however, and no specific cause has been identified.

Red tides, which in other areas may result in fish kills and/or restrictions on the consumption of shellfish, have not occurred in the New Bedford area[b].

No information is available regarding mass mortalities of invertebrates in the New Bedford area.

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[a] Personal communication (phone) on September 8, 1981, by Mr. M. Griben with Andrew Kolek, Massachusetts Division of Marine Fisheries, Sandwich, MA.

[b] Personal communication (phone) on September 14, 1981, by Dr. L. McCrone with Mr. Richard Packard, Massachusetts Department of Environmental Quality Engineering, New Bedford, MA.

Question 7-11. Have any other adverse ecological impacts been noted?--

The applicant supplies a negative response to Question 7-11.

Although the applicant's studies of some biotic groups (i.e., plankton, fishes, shellfish) are quite limited, the data supplied by the applicant and information collected as part of this evaluation do not reveal the presence of impacts not addressed in the previous questions. It should be emphasized, however, that more extensive surveys would be required to demonstrate or predict impacts of either the existing or proposed discharges.

Question 7-12. Has the discharge enhanced, or will it perpetuate, adverse conditions resulting from other pollution sources?--

The applicant does not respond to this question because the receiving waters in the vicinity of the proposed outfall are not considered by the applicant to be stressed. No mention is made of the receiving waters in the vicinity of the existing outfall.

Information acquired as part of this evaluation strongly suggests that New Bedford Harbor, including the vicinity of the existing outfall, should be considered to be a stressed environment. Severe restrictions have been placed on the commercial and recreational harvesting of certain fish and shellfish species in New Bedford Harbor due to coliform bacteria and PCB contamination (see Commercial and Recreational Fisheries subsection of Part

B, Section 6 above). The sources of the bacterial contamination include both combined sewer overflows and the existing sewage outfall. The sources of the PCB contamination were primarily industrial discharges, but also included PCB emissions in the New Bedford sewage effluent. In addition, there is evidence that some pollution of the harbor is occurring from heavy metal accumulations (see Bioaccumulation subsection of Part B, Section 6 above). It seems likely that the New Bedford sewage discharge has contributed to all of these pollution problems, but the applicant does not present adequate information to estimate the contribution of sewage effluent relative to other pollutant sources.

Due to the severe widespread contamination, New Bedford Harbor should be considered stressed. Somewhat surprisingly, however, Kolek and Ceurvels (1981) reported that:

> "We have observed no overt effects of PCB uptake on marine organisms in the area, even though some contained PCB levels exceeding 100 times the FAL. Gross inspection revealed no abnormalities or indications of disease symptoms in any of the animals sampled and/or observed. Seasonal development of the reproductive organs of the finfish examined appeared to be normal."

Nevertheless, removal of the sewage discharge from its present location can only improve the stressed conditions. Even if there are no overt effects to be mitigated, reduction in at least some of the inputs of the various pollutants may hasten the recovery of the system.

There remains, however, some question over whether the receiving waters in the vicinity of the proposed outfall should be classified as stressed. Present restrictions on commercial and recreational fishing and shellfishing extend nearly to the site of the proposed outfall (see Figure 24), and Kolek and Ceurvels (1981) report that lobsters having PCB concentrations exceeding the Federal Action Level have been collected at a station beyond the restricted zone and near the proposed outfall. Additionally, Stoffers et al. (1977) characterize sediments in the vicinity of the proposed outfall as being "slightly contaminated" based on copper concentrations. Any further releases of contaminated wastewater at the site of the proposed outfall may aggravate a potentially stressed environment. The applicant should have supplied reasons why it contends that its proposed discharge will not perpetuate adverse ecological alterations due to other sources of pollution.

Question 7-13. Will the proposed improvement eliminate adverse ecological impacts attributable to the existing discharge?--

The applicant originally supplied a negative response to Question 7-13; however, in a letter from the Major of the city of New Bedford, John A. Markey, to the U.S. EPA 301(h) Review Group, dated January 2, 1980, the response was changed to an affirmative one.

Phytoplankton--The applicant does not refer specifically to phytoplankton in response to this question, but it is apparent from the responses to Questions 7-1, 7-2, and 7-3 that the applicant believes that phytoplankton have not been adversely affected by the existing discharge. Hence, the applicant probably contends that there is no adverse ecological impact on phytoplankton to be eliminated by the proposed improvement.

As discussed in detail in the evaluation of Part B, Section 6, and in the responses to Questions 7-1, 7-2, and 7-3 above, the phytoplankton sampling program was so limited in scope that a definitive judgment regarding possible adverse impacts of the existing discharge on phytoplankton could not be made. Nevertheless, if there are presently adverse impacts on phytoplankton in the vicinity of the existing outfall, they would likely be eliminated by the proposed outfall relocation. It also appears likely that the potential for adverse impacts on phytoplankton at the site of the proposed discharge would be markedly less than at the existing discharge site, due to greater anticipated dilution at the proposed site.

The failure to investigate possible enhancement or inhibition of primary production by the existing discharge is a serious omission which precludes accurate prediction of such effects at the proposed outfall. The restriction of the effluent plume to subsurface depths during periods of maximum stratification should reduce the likelihood of enhancement or inhibition of phytoplankton primary production at the site of the proposed outfall, but it is impossible to predict what will happen during periods when stratification is insufficient to restrict the effluent plume to subsurface depths.

In summary, too little information is supplied by the applicant to verify either its prediction of lack of intereference with the protection and propagation of a BIP of phytoplankton, or its prediction of a lack of differences in the structure and function of the phytoplankton community beyond the ZID.

Zooplankton--While the applicant does not refer specifically to zooplankton in response to this question, it is clear from the responses to Questions 7-1, 7-2, and 7-3 that the applicant believes that zooplankton have not been adversely affected by the existing discharge. Hence, the applicant probably contends that there is no adverse ecological impact on zooplankton to be eliminated by the proposed improvement.

As discussed in detail in the evaluation of Part B, Section 6, and in the responses to Questions 7-1 and 7-2 above, the zooplankton sampling program was so limited in scope that no definitive judgment can be made regarding possible adverse impacts of the existing discharge on zooplankton. Nevertheless, it appears likely that the potential for adverse impacts on zooplankton at the site of the proposed discharge would be markedly less than at the existing discharge, due to the greater anticipated dilution at the proposed site. However, too little information is supplied by the applicant to verify either its prediction of lack of intereference with the protection and propagation of a BIP of zooplankton, or its prediction of a lack of differences in the structure and function of the zooplankton community beyond the ZID.

Benthic Infauna--The applicant states that:

> "the marine benthic community as well as other communities will be minimally affected, even within the Zone of Initial Dilution (ZID) at the improved discharge/diffuser location. The predicted settling rates for the suspended solids remaining in the primary effluent should be less than the natural ambient settling rate at the new diffuser location."

and that:

> "the spatial extent of the degraded area will approximately be within the ZID. Within the ZID area, the indigenous benthic community will be disturbed and some species may be eliminated as others become established. The net effect will likely be some measureable decrease in benthic standing stocks within this area."

While the applicant predicts that a "degraded area" may occur within the ZID of the proposed discharge, the applicant also maintains that the proposed discharge will not interfere with a BIP beyond the ZID.

The applicant fails to provide a theoretical or empirical basis for predicting that settling rates of effluent solids, which are predicted to be less than natural sediment deposition rates, will result in minimal impacts on benthic infauna. The applicant does not compare predicted sediment accumulation rates due to the proposed discharge with natural conditions. It is conceivable that under some conditions sewage solids deposition rates that are less than ambient sediment deposition rates could result in adverse impacts on benthic infauna. Moreover, high initial dilution and prevailing offshore transport, as postulated for the proposed discharge by the applicant, do not in themselves ensure that adverse impacts on benthos will be minimal.

The results of the 1979 benthic surveys provided no evidence that adverse impacts of the existing discharge are limited to the ZID. Rather, if station coordinates provided by the applicant are correct, then the existing discharge may cause a major reorganization of benthic infaunal community structure at distances up to about 167 m (548 ft) beyond the ZID boundary (i.e., at Station B1).

In Appendix XI, the applicant compares the proposed discharge with a discharge off Point Loma, California. Since no "degraded" area was found by Bascom et al. (1978) around the Point Loma outfall, the applicant concludes that adverse impacts of the proposed New Bedford discharge will be limited to bottom areas within the ZID. It was concluded earlier in this evaluation that the applicant's prediction of benthic impacts based upon a comparison of the proposed discharge with the Point Loma discharge is inappropriate. Thus, the applicant has little valid basis for suggesting that adverse impacts of the proposed discharge on benthic infauna will be limited to the ZID.

Although the applicant offers a fair interpretation of the effects of the existing discharge on benthic infauna (see above, Part B, Section 6, Benthic Infaua), the applicant's prediction of impacts caused by the proposed discharge is incomplete. For example, although the applicant recognizes that there may be "some measurable decrease in benthic standing stocks" within the ZID of the proposed discharge, the applicant fails to discuss the potential decrease in species richness and diversity which may be caused by the discharge. In addition, the applicant has not addressed the potential for pollution-resistant species to dominate communities within the ZID of the proposed discharge. Recall that the opportunistic polychaete worm Nereis succinea appears to dominate the fauna near the existing outfall.

Quantitative relationships between initial dilution or net sediment accumulation rates and impacts on benthic communities cannot be postulated at this time, but it seems likely that completion of primary treatment facilities and relocation of the outfall will mitigate some effects of the existing discharge. Based on the available data, however, it is impossible to predict the extent to which the proposed improvement will eliminate possible adverse impacts of the existing discharge.

Rocky Intertidal--After discussing potential impacts on benthic communities, the applicant states that "It is predicted for the other communities living in proximity of the proposed improved outfall, that there will be minimal impact and limited to the ZID." Since no intertidal habitats are found in the immediate vicinity of the proposed diffuser, the applicant's statement implies that there will be no impact of the proposed discharge on intertidal communities.

Based on an assessment of impacts caused by the existing discharge, the applicant predicts that the proposed discharge will cause no perturbations of intertidal fauna and flora (see Appendix XI of the application). However, the applicant's assessment of intertidal impacts caused by the existing discharge is inadequate because of the limitations of sampling and study design discussed earlier in this evaluation. Potential impacts of the proposed discharge on intertidal communities are therefore inadequately assessed by the applicant.

Because the proposed discharge will be located farther from intertidal habitats than the existing discharge, it seems likely that any impacts of the proposed discharge on intertidal communities will be less than those presently caused by the existing discharge. Based on the information provided by the applicant, however, it is difficult to determine if the proposed outfall improvements and relocation will entirely eliminate adverse impacts of the existing discharge on intertidal communities (if any adverse impacts presently occur).

Fishes--The applicant predicts that "for the other communities [with the exception of benthos] living in proximity of the proposed improved outfall,...there will be minimal impact and limited to the ZID." The applicant does not specify the types of impacts which may occur to the fish community within the ZID of the proposed discharge. The nature of the fish community at the proposed site is not adequately characterized by the applicant. If fish attraction is occuring at the existing discharge, a similar situation may develop at the proposed outfall. Furthermore, the applicant does not address the consequences of potential PCB contamination upon the fishery resources in the vicinity of the proposed site. It is possible that commercial and recreational fisheries may be restricted if high PCB levels occur in fish, shellfish, or crustacean tissues.

Therefore, it is not clear that adverse impacts on fishes and fisheries associated with the existing discharge will be eliminated at the proposed outfall.

Shellfish--The applicant predicts that "for the other communities [with the exception of benthos] living in proximity of the proposed outfall,...there will be minimal impact and limited to the ZID." The applicant does not specify the types of impacts which may occur in the shellfish community within the ZID of the proposed discharge. The nature of the shellfish assemblage at the proposed site is not adequately characterized by the applicant. However, if shellfish do inhabit the site, they may be potentially impacted by the low-levels of PCBs occurring in the effluent of the proposed discharge. As described in the Commercial and Recreational Fisheries section of this evaluation, shellfish in New Bedford Harbor have been contaminated by PCBs and coliform bacteria. While improved treatment should reduce coliform bacteria levels at the proposed site, PCBs may remain a problem. Therefore, it is not evident that the shellfish PCB contamination problems in the vicinity of the existing discharge will be eliminated at the proposed site.

Section 8. Recreational Impact Assessment

Identification of Recreational Activities--

The applicant reports that the area of Buzzards Bay around Clarks Point and New Bedford supports numerous recreational activities, including:

- Fishing and shellfishing
- Boating
- Swimming and wading
- Picnicking and other beach activities.

The location of some of these activities is shown in Figure 27.

The applicant identifies general reference sites with similar recreational activities along the coastline of Massachusetts. As with the New Bedford area, beaches and recreational areas that are in close proximity to large urban populations reveal pollution impacts on recreation. The pollution which has adversely affected some recreational activities in the New Bedford Harbor area cannot be entirely attributed to the existing effluent discharge. The applicant predicts that extension of the outfall will eliminate the contribution of the discharge to the problem in the harbor area.

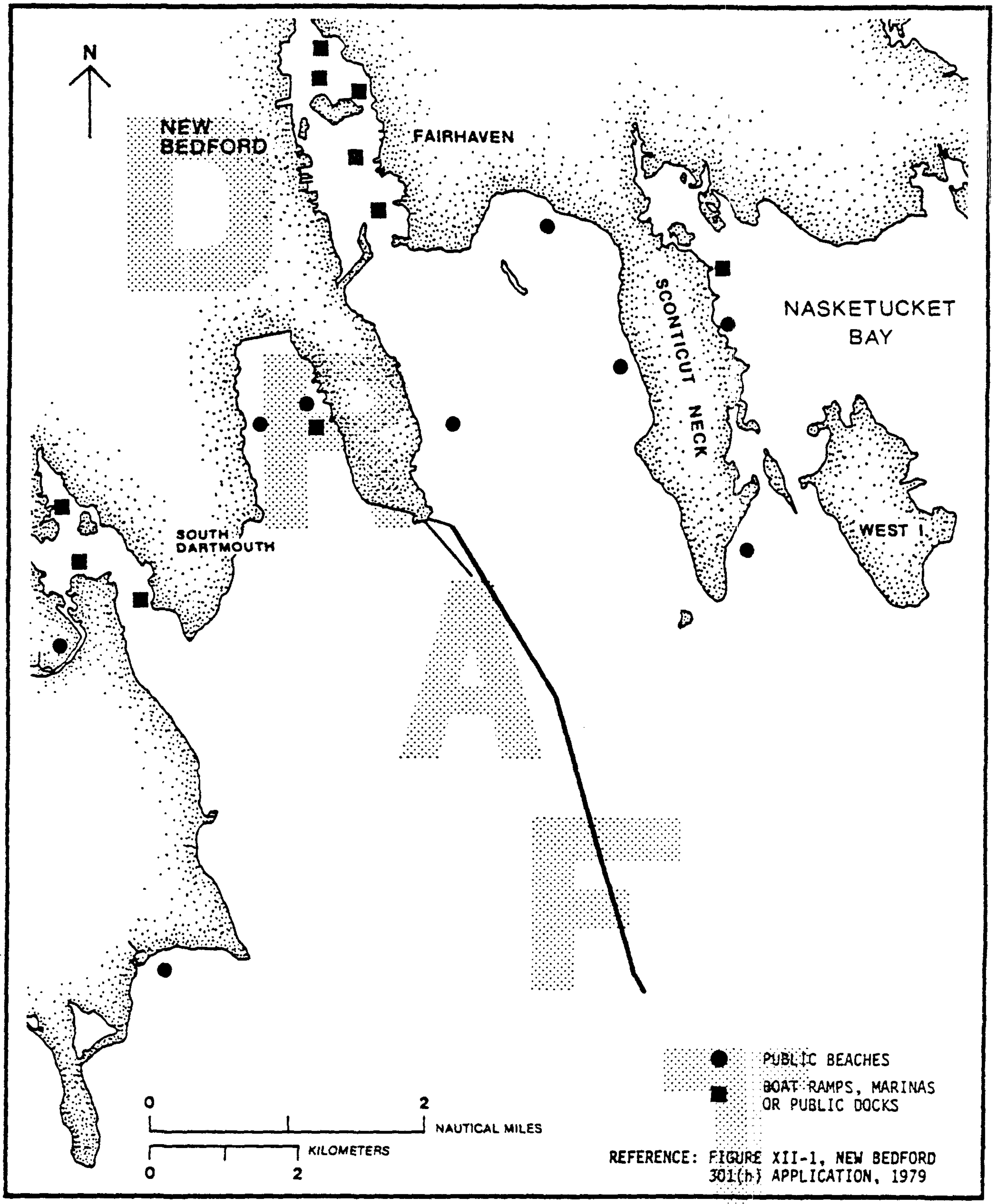

Figure 27. Recreational activities near the existing and proposed New Bedford, MA, plant outfalls.

The applicant does not provide any information on the extent of recreational activities in the area in terms of the number of boats moored in the area, person-day use of the beaches, or statistics on the type and quantity of fish or shellfish harvested. The location of swimming and fishing areas is not identified by the applicant.

Impacts on Fishing--

The applicant indicates that the proposed outfall and improved discharge are not expected to have any adverse effects on fish and shellfish due to low concentrations of contaminants and expected dilutions. However, no data are presented in this section which indicate that possible impacts on fish or shellfish were thoroughly examined. Recreational harvest information was not provided nor were the results of any studies concerning the occurrence of disease or heavy metals in organisms found near the outfall. This is discussed in more detail in Part B, Section 6.

The applicant states that the harvesting of clams is currently restricted in some areas due to high coliform bacteria counts and the presence of PCBs. The State Department of Environmental Quality Engineering (DEQE) attributes partial responsibility for the closure to the existing New Bedford outfall and the lack of reliability of the local treatment plants. In 1977, DEQE (according to the applicant) issued a warning that it was not advisable to harvest and consume shellfish, lobsters, or any bottom-feeding fish in some areas off New Bedford due to high PCB levels. As discussed in the Commercial and Recreational Fisheries portion of Part B, Section 6 of this evaluation, the Massachusetts Department of Public Health (MDPH) not DEQE, issued the warning. In 1979, MDPH closed several areas near New Bedford due to observed PCB levels. Elimination of PCB use by industries in the service area has reduced effluent concentrations to trace levels; however, the chemical is persistent and the effects will be felt for some time. The improved discharge should reduce the contribution of the New Bedford plant to the coliform-related problems in the area.

Restrictions on Shellfish and Fish Harvesting--

As stated above, harvesting is restricted in some areas near the discharge. MDPH issued a warning in 1977 concerning harvesting and consuming of lobsters and bottomfish. The Department of Public Health closed New Bedford Harbor and adjacent areas of Buzzards Bay in 1979 due to PCB levels. The inner harbor area is closed to the taking of all fish, shellfish, and lobsters. The outer harbor area, including the vicinity of the existing discharge is closed to the harvesting of bottom-feeding fish and lobsters. In the adjacent area of Buzzards Bay (but inshore of the proposed discharge), taking lobsters is prohibited. No other federal, state, or local restrictions have been placed on fish or shellfish.

Limitations on Toxic Substances in Edible Fish and Shellfish--

The applicant identifies the toxic pollutant limitations set by the Food and Drug Administration (FDA), but does not address whether these limits are exceeded in organisms near the existing outfall. Studies of PCB levels in the area have shown that FDA limits are exceeded in some organisms (Kolek and Ceurvels 1981), and indicate the need for further examination of the problem. Similarly, no projections of compliance with the FDA limits are made for the area of the proposed discharge. No other limitations are known to exist.

Impacts on Recreational Boating and Other Water-Related Activities--

The applicant indicates that the existing outfall has had no adverse effects on swimming, wading, boating, picnicking, or other sport activities. There has been only one beach closure in the past 10 years, and it was not due to the effluent discharge. East Beach in New Bedford was closed due to high coliform bacteria counts resulting from a pumping station malfunction which discharged raw wastewater near the beach. The applicant states that water-related activities will not be affected by the proposed discharge.

Restrictions on Water-Contact Sports and Beach Use--

No restrictions have been placed on any water-contact sports or other beach activities due to the New Bedford treatment plant discharge. Provided chlorination occurs as necessary, the new outfall should also cause no limitations on beach use.

Discharge Compliance with Water Quality Standards--

The applicant states that no water quality standards have been promulgated specifically to protect recreational activities but that minimum criteria have been identified which are applicable to the aesthetics of all state waters. Because the New Bedford plant is not currently operating properly, these minimum standards are not being met. According to the applicant, once the treatment plant and discharge improvements are completed, all standards will be met.

PART C

PART C - DESCRIPTION OF MONITORING PROGRAM

Section 1. Biological Monitoring Program

The applicant describes the proposed biological monitoring program in Appendix XIII. The applicant proposes to conduct studies of benthic macrofauna, demersal fishes, and bioaccumulation at both the existing and proposed outfall sites. The applicant does not provide justification for the selection of the proposed biotic groups.

Phytoplankton--

The applicant does not propose monitoring phytoplankton communities as part of the biological monitoring program. As discussed in detail in Part B, Section 6, of this evaluation, the applicant has not adequately assessed potential impacts of the existing discharge on phytoplankton. Limitations of the previous phytoplankton study included inadequate characterization of a BIP, lack of information on seasonal variations, omission of measurements of primary productivity and/or community biomass, and too few stations in the vicinity of the existing outfall.

Before discharge through the new outfall begins, the applicant should attempt to determine whether phytoplankton communities in the vicinity of the existing outfall are altered or not, and whether or not primary production is currently enhanced (or inhibited) by the addition of nutrients (or potentially toxic substances) in the sewage effluent. In addition, the applicant should conduct phytoplankton sampling at the site of the proposed outfall both before and after initiation of effluent discharge through this outfall. With samples collected both before and after diversion of the effluents to the new outfall, the applicant should be able to document any changes which may occur at the site of the existing outfall in response to the cessation of effluent discharge and any changes which may occur at the proposed site in response to the initiation of effluent discharge there. A recommended phytoplankton monitoring program is described in greater detail below.

Study Design--Phytoplankton sampling at each site should include taxonomic collections, measurements of chlorophyll a concentrations (as an estimator of community biomass), and estimation of primary productivity. Measurements of chlorophyll a concentrations in the receiving water at several stations at varying distances from the outfall will be useful in examining the extent and periodicity of any phytoplankton enhancement which may occur in the vicinity of the outfall. Because measurement of chlorophyll a concentrations alone will not permit evaluation of possible inhibitory effects of the sewage effluent on phytoplankton, it will also be necessary to conduct simulated in situ measurements of phytoplankton primary productivity.

Bimonthly sampling would be required for adequate assessment of outfall-related effects on the phytoplankton, although monthly samples would be preferable. Sampling should especially occur during periods of minimum stratification, since this is when the effluent plume may be expected to surface at the site of the proposed outfall.

Sampling stations should be located at varying distances both upcurrent and downcurrent from the outfalls in order to compensate for possible lag times in the response of phytoplankton to effluent inputs. Sampling should also be conducted at reference or control stations far removed from the influence of the sewage discharge.

As part of the biomonitoring program, the applicant should define a BIP of phytoplankton for the area, as this was not done in the BCS of the application. The parameters used to define a BIP should include, but not necessarily be limited to, species composition, abundance of major species, species richness, chlorophyll a concentrations, and primary productivity levels.

Sampling Stations--With the information presently available, it is not possible to specify precise sampling station locations. The applicant should consider the direction of current flow when deciding on these locations. Stations should be positioned just upcurrent and downcurrent of the ZID boundary at each outfall. It is not necessary to sample phytoplankton within the ZID since these small cells are advected through and beyond the ZID by movements of the water. Additional stations should be located approximately 500 m (1,640 ft) and 1,000 m (3,280 ft) upcurrent and downcurrent from the ZID of each outfall. Sampling should also be conducted at two reference stations: one located east of West Island in Nasketucket Bay in a similar depth of water as the existing outfall, and one outside Nasketucket Bay in a similar depth of water as the proposed outfall. The latter station should be at least 8.0 km (5.0 mi) northeast of the proposed outfall, so that it would not be expected to be affected by the discharge of sewage effluent, and so that it may serve as an adequate control for stations near the proposed discharge.

Sampling Procedures--Sampling procedures should follow recommendations of *Stofan and Grant (1978). Sampling depths should be selected to* correspond with fixed percentages (e.g., 100 percent, 50 percent, 25 percent, 5 percent) of the incident light at the surface. Extinction coefficients may be estimated through the use of either a photometer or a Secchi disc. A water bottle sampler is recommended for the collection of samples for analysis of phytoplankton parameters. Replicate samples should be collected and processed separately to facilitate statistical analysis.

Chlorophyll a concentrations may be determined either fluormetrically or spectrophotometrically, although the former method, if used, must be standardized against the latter method. In addition, the water should be used for simulated in situ measurements of productivity (UNESCO 1973), and a subsample should be preserved for later taxonomic analysis. If samples are also taken for the analysis of dissolved oxygen and/or ammonium concentrations, it may be possible to determine the location of the effluent plume and estimate where the greatest impact on phytoplankton may be expected to occur.

The applicant should give considerable attention to an accurate qualitative and quantitative analysis of the taxonomic samples. Techniques utilized should follow recommendations described in detail in Sournia (1978).

Data Analysis--Replicate determinations of phytoplankton parameters at each station-depth will allow a sensitive test for differences among sampling stations, depths, and dates. For chlorophyll *a*, primary productivity, and species richness, a set of values can each be entered into a three-way ANOVA classification to test for significant treatment effects due to station location, sampling depth, and time (cf. Sokal and Rohlf 1969, Zar 1974). Counts of individual species and/or total cell counts at each station-depth also can be included in an ANOVA design. Because ANOVA examines treatment effects on only one dependent variable at a time, the data should also be analyzed using a multivariate technique such as multiple discriminant analysis (Cooley and Lohnes 1971, Allen and Koonce 1973). In this case, the data could be grouped by station locations, and the method would determine a discriminant score for each set of variables which best separates all samples taken at one station from all samples associated with all other stations.

Comparisons among years or discharge periods (before or after initiation of discharge through the new outfall) can be accomplished by one-way ANOVA or a nonparametric analog such as the Kruskal-Wallis multiple comparisons test (Sokal and Rohlf 1969).

Species composition data should be subjected to cluster analysis for classifying algal communities by station locations, depths, or both [see examples in Boesch (1977)]. Given only information on species presence or absence, Boesch (1977) recommends use of the Dice or Jaccard similarity coefficient. If counts of individual species are determined, a quantitative measure of resemblance such as the Bray-Curtis similarity coefficient should be used (Boesch 1977).

Particular attention should be given to comparisons between stations in the vicinity of the existing outfall and the reference station in Nasketucket Bay. In addition, comparisons should be made between the phytoplankton parameters at stations in the vicinity of the proposed outfall and those at the reference station outside Nasketucket Bay. Other comparisons of interest will be conditions in the vicinity of each outfall before and after initiation of sewage discharge through the new outfall.

Zooplankton--

The applicant does not propose monitoring zooplankton communities as part of the biological monitoring program. It is not recommended that zooplankton be monitored unless results of the phytoplankton monitoring program suggest that the existing or improved discharge is having a significant adverse effect on planktonic organisms.

Benthos--

Preface--The applicant is applying for a 301(h) modification based on an improved, relocated discharge. Quarterly biological monitoring is required at the existing discharge site and at the proposed discharge site under the 301(h) regulations. Monitoring at the existing discharge site should continue until that discharge ceases. Monitoring at the proposed discharge site should be designed to collect baseline data for a minimum of 1 year prior to initiation of the discharge, and to monitor biological conditions as improvements other than outfall relocation are completed. Monitoring at the proposed outfall site shall continue indefinitely as a means of demonstrating that the discharge complies with 301(h) requirements.

Station Locations--The applicant proposes to monitor benthic infauna at Stations 1-7 shown in Figure 28. The applicant states that stations for monitoring the effects of the existing discharge will be located "within and beyond the ZID, at the reference site utilized in the 301(h) demonstration and near the harbor mouth..." (Stations 1, 2, 3, and 4, respectively, in Figure 28).

The applicant's proposed location of a station within the ZID is appropriate. Given the location for Station 2 shown in Figure 28, that station would be situated more than 200 m (656 ft) from the outfall. Since the ZID of the existing discharge has an 8.8-m (29-ft) radius according to calculations performed during this evaluation, Station 2 as proposed by the applicant would be more than 190 m (623 ft) from the ZID boundary. At this position, Station 2 would not satisfy the requirement for a ZID-boundary station. Station 2 should be repositioned just beyond the ZID boundary of the existing discharge by perhaps 5-20 m (16-66 ft).

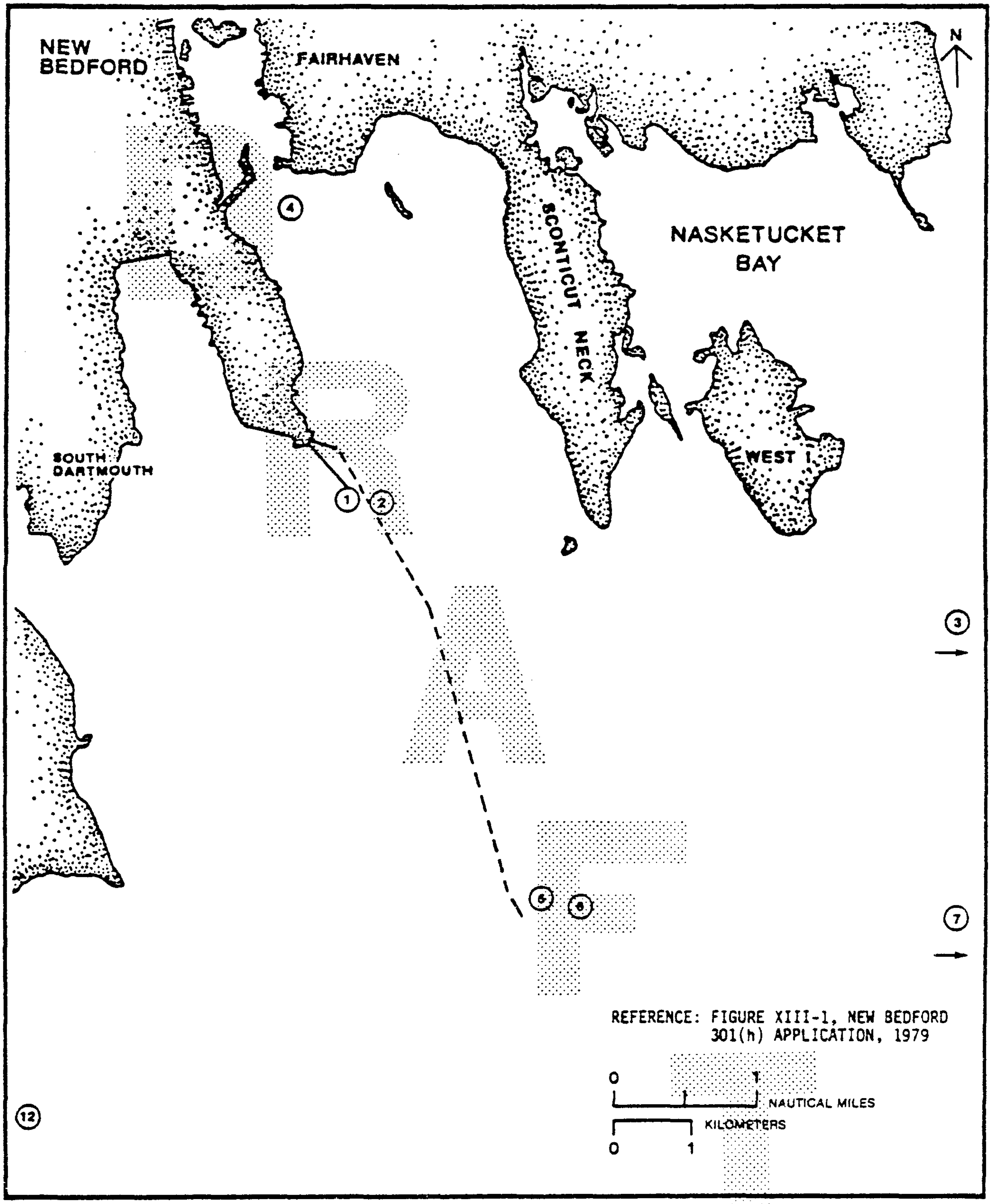

Figure 28. Location of proposed biological monitoring stations, New Bedford, MA.

According to the applicant, Station 3 is located at the same site as Station B17 used in the August, 1979, benthic survey. Although Nasketucket Bay appears to be a suitable area for location of control stations, Station 3 is located at a shallower depth than the existing outfall. The applicant should reposition this reference site at a water depth similar to the existing outfall, perhaps off a land projection such as Mattapoisett Neck.

The applicant does not justify locating a sampling station "near the harbor mouth" (Station 4). It is herein suggested that additional stations be occupied near the existing discharge in lieu of Station 4 for the following reasons. In the Biological Conditions Summary, the applicant concludes that impacts of the existing discharge on benthic infauna are confined to an area within a radius of somewhere between 25 m (82 ft) and 640 m (2,100 ft) beyond the outfall. Spatial patterns of impacts associated with the existing discharge were not adequately assessed in the Biological Conditions Summary, thereby precluding a definitive assessment of the areal extent of community changes. The addition of stations upcurrent and downcurrent from the outfall would allow the determination of gradients in community response and overall spatial extent of any discharge impacts, and would alleviate existing information gaps.

The applicant proposes to monitor the effects of the proposed discharge by sampling benthic infauna within the ZID, beyond the ZID, and at a reference site in Nasketucket Bay (Stations 5-7 in Figure 28). Although the applicant's text describes appropriate locations for sampling stations, the location of Station 5 in Figure 28 does not correspond to the text description. From Figure 28, Station 5 is located about 340 m (1,116 ft) from the proposed outfall, and about 311 m (1,020 ft) beyond the ZID according to ZID dimensions calculated as part of this evaluation. Similarly, Station 6 is located too far from the outfall to serve as a ZID-boundary station. Stations 5 and 6 should be positioned within the ZID and at the ZID boundary, respectively, at distances similar to those suggested for the within-ZID and beyond-ZID sites near the existing discharge.

Presumably, the putative reference site for the proposed discharge, Station 7, corresponds to Station B20 of the August, 1979, survey, although the applicant does not so indicate. An exact location for Station 7 is not given in the applicant's figure of sampling station locations (see Figure 28). Station B20 is located in about 13.7 m (45 ft) of water in Nasketucket Bay. Since the proposed outfall will discharge at a water depth of 16.7 m (55 ft), Station B20 and presumably Station 7 are situated at depths slightly shallower than the proposed diffuser. The general location of Station 7 in Buzzards Bay appears suitable for a control station to evaluate the effects of the proposed discharge, but the station should be relocated to a more appropriate depth.

As described above for the existing discharge site, the applicant should consider locating additional stations near the proposed outfall. One or more transects through the discharge area would be useful for assessing the spatial pattern of benthic communities potentially impacted by the discharge. Furthermore, it is suggested that all sites be sampled to ensure that the sediments and hydrography are similar.

Sampling Procedures--The applicant indicates that monitoring will be conducted at the existing discharge site "as soon as possible after the receipt of a waiver" and until the discharge ceases. At that time, the applicant plans to decide if studies at the existing outfall area will be continued. The applicant proposes to begin the monitoring program at the new outfall site 1 year before operation of the outfall and continue sampling for 2 years after initiation of the discharge. Sampling will be conducted on a quarterly basis at both the existing and the proposed discharge sites. The sampling schedules proposed by the applicant for the benthic monitoring surveys are acceptable. Although the applicant is not required to monitor benthic infauna at the existing discharge site after cessation of that discharge, the applicant is urged to continue monitoring, thereby documenting faunal recovery.

The applicant proposes to collect five replicate samples at each station using a modified van Veen grab sampler. The applicant also proposes to process benthic samples following methods used in previous benthic infaunal surveys described in Appendix XI of the application. The procedures consisted of washing the contents of each 0.04 m^2 (0.43 ft^2) sample through a 0.5-mm (0.02-in) sieve, fixing the organisms and debris in 10-percent formalin, and later preserving this material in 70-percent isopropanol. Only three of the five replicate samples were sorted and the organisms identified and enumerated. The remaining samples were placed in storage for processing "should greater statistical precision be required." The applicant does not indicate what quality control procedures would be used during sample processing, but states that "Upon request, the applicant will provide a copy of the Quality Control manual utilized during the conduct of the monitoring program." The applicant indicates that measurements of DO, pH, temperature, and salinity will be made when the benthic samples are collected and that tidal stage will also be recorded.

To ensure adequate sample size and quality, it is herein suggested that a chain-rigged, 0.1-m^2 (1.1-ft^2) van Veen grab or a 0.1-m^2 (1.1-ft^2) Smith-McIntyre grab be used for sample collection. As discussed in Part B, Section 6, five replicate samples with this areal coverage are often needed at each station to accurately assess species composition of coastal benthic macrofaunal communities. The applicant's proposed sample size [three replicates totalling 0.12 m^2 (1.3 ft^2) of bottom] may be too small by at least a factor of four. In lieu of simply collecting five replicate grab samples per station, the applicant may elect to perform a sensitivity analysis to determine the minimum number of replicates which will yield an acceptable level of statistical sensitivity. The applicant is referred to Gonor and Kemp (1978) and Saila et al. (1976) for appropriate analytical techniques.

The applicant does not specify any aspects of a quality assurance/quality control program for benthic sampling (e.g., reference collection of benthic invertebrates, field log program, data recording procedures, sample resorting techniques, data transfer methods, taxonomic verification). Hence, no evaluation of the applicant's quality assurance/quality control program is possible.

Taxonomic Procedures--The applicant does not describe the procedures to be followed in identifying and enumerating organisms collected in benthic grab samples. Since the applicant does not specify the taxonomic references to be used or the taxonomic qualifications of the survey personnel, no evaluation of proposed taxonomic procedures is possible. However, it should be mentioned that taxonomic procedures employed during previous benthic surveys appeared to be adequate.

Data Analysis--The applicant states that structural analyses of the communities will include the following:

- Species composition
- Abundance (number/unit area)
- Trophic position and biomass (weight/unit area) of dominant organisms
- Dominance
- Species diversity.

Each of the analyses proposed by the applicant is appropriate for the description of species composition or community structure of benthic macrofauna, but additional analyses are warranted. A full analysis of trophic structure should compare trophic interactions of dominant taxa between sites, the influence of keystone species (sensu Paine 1969), and the potential impacts of sewage effluent on trophic structure of benthic communities. Therefore, in addition to the proposed analyses, the applicant should compare the similarity (species composition and abundance indices) between and among stations and replicates to determine differences and changes in the composition and abundance of the benthic community possibly related to the outfalls. Any future cluster analyses and nodal analyses performed by the applicant should incorporate modifications suggested earlier in this evaluation (see Part B, Section 6). The applicant may also consult Boesch (1977) for appropriate analytical techniques. The relationships among station groups identified by cluster analysis should be fully interpreted using available information on the ecology of dominant species. Such interpretations will illuminate possible impacts of sewage effluents. Multivariate techniques such as factor analysis or discriminant function analysis could also be used to identify station groupings by relating physical-chemical parameters to characteristics of the biological communities (e.g., Cooley and Lohnes 1971).

Fishes--

The applicant indicates that the purpose of the fish monitoring plan will be to assess the status of the commercial and recreational fish stocks which may be potentially impacted by the discharge. The proposed plan calls for fish monitoring to begin at the existing discharge as soon as possible after receipt of a 301(h) modification. Monitoring will be conducted on a quarterly basis until the current discharge ceases operation. Duplicate trawls will be conducted at each of three stations with respect to the existing discharge, i.e., within ZID (Station 1), ZID boundary (Station 2), and reference (Station 3) (see Figure 28). As previously indicated under the benthos monitoring plan, Station 2 as designated by the applicant is not located at the ZID boundary. Therefore, the applicant should reposition the site to conform to the boundary location.

Field procedures will include weighing and measuring the collected fish, noting species composition of the haul as well as disease symptoms and abnormal coloring. "Other observable factors" (unspecified) will also be recorded according to the applicant. Statistical analysis of the monitoring data will employ both parametric and nonparametric techniques.

The monitoring plan at the proposed discharge site will be based upon the same procedures developed for the existing outfall. Stations will be located within the ZID (Station 5), at the ZID boundary (Station 6), and at a control site (Station 7) (see Figure 28). Monitoring will commence 1 yr prior to discharge initiation and continue for a 2-yr period once the relocated outfall is operational.

Conceptually, the fish monitoring program proposed by the applicant is appropriate; however, the absence of an adequate fish data base requires a more detailed, intensive program. That is, the applicant's 1-day 1979 study in New Bedford Harbor and Nasketucket Bay could not define the natural spatial and temporal variabilities associated with the indigenous fish community. Without identifying the natural variability of the fish assemblages, it would be difficult to ascertain whether changes observed during the course of a monitoring program were due to natural or discharge-related effects. Therefore, the applicant should optimally design the monitoring program to assess species diversity, abundance, trophic position and biomass of dominant species, and test for bioaccumulation of toxicants in finfishes. These sampling parameters should be included in addition to those identified by the applicant in the proposed plan.

The applicant should also attempt to periodically analyze fish catch and effort data from the area of the outfalls in order to determine trends which may be associated with the presence of the discharge. For example, fish catch and effort may increase in the vicinity of the relocated outfall if fish are attracted to the area. On the other hand, the discharge area may be aesthetically unappealing and anglers may avoid it.

A second concern regarding the proposed fish monitoring plan is the location of the reference or control stations. In Appendix XIII of the application the applicant presents Figure XIII-1 which indicates the locations of the proposed monitoring stations. Specific locations for Station 3 (existing discharge control) and Station 7 (relocated discharge control) are not indicated. The applicant indicates under the benthos monitoring plan that Station 3 corresponds to "the reference site utilized in the 301(h) demonstration." This is assumed to be Station B17 (see Figure 20). This benthic control site is located in water shallower than that of the existing discharge. A specific location for Station 7 cannot be inferred from the applicant's discussion. Control stations should be located in areas where physical, chemical, and biological characteristics are similar to those which would be expected to occur at the discharge site in the absence of pollution. For a valid comparison to be made between control and discharge fish communities, environmental conditions should be as similar as possible, other than the presence of pollutants at the control. Depth and substrate are particularly important in this regard. Fish communities are often influenced by these characteristics.

In summary, the applicant's proposed fish monitoring program should be expanded to establish baseline conditions of the indigenous fish community in the vicinity of both the existing and proposed outfalls. This is required in order that the natural variability in the fish stocks may be differentiated from that potentially induced by the discharges. Furthermore, the applicant should attempt to locate control stations in areas where depths and substrates are similar to those encountered at the discharge sites.

Bioaccumulation--

The applicant proposes to conduct bioaccumulation studies at both the existing and proposed outfall sites. The proposed station locations are the same as for fishes (i.e., Stations 1, 2, and 3 at the existing outfall; Stations 5, 6, and 7 at the proposed outfall site). These station designations suffer from the same limitations as identified in the previous sections.

The applicant proposes to expose filter-feeding bivalve molluscs in cages placed on the bottom. The applicant states that cages will only be placed on the bottom since "water quality standards will be met within the ZID." The reasoning for this statement is unclear since the ZID is a volume of water extending to the seafloor. It is recommended that exposures of caged molluscs be conducted at a *minimum* of two depths, near the bottom and at a point in the water column corresponding to the calculated plume trapping level. Organisms exposed only at the bottom could be expected to accumulate toxic chemicals at a rate which is primarily dependent upon the degree of contamination of bottom sediments. Since residual contamination of bottom sediments could exist for extended periods following source control of toxic chemicals, the levels in bottom organism tissues may not give a reliable indication of source control effectiveness. The relatively high differential uptake of toxic chemicals as a function of exposure depth has been demonstrated by Young et al. (1976).

The applicant states that bioaccumulation tests will be conducted quarterly with 1-mo exposure periods. Two cages of 10 molluscs each will be placed at each location. This exposure design is basically adequate; however, extension of the exposure period to 6 weeks to allow for tissue equilibration should be considered. Other aspects of study design such as selection of test organisms, collection of concurrent sediment samples, and analysis of chemical species are also adequate.

The applicant states that quantitative data will be analyzed by parametric statistical techniques such as ANOVA and SNK tests. "Observational types of data" will be analyzed using chi-square statistics. Prior to utilization of parametric statistics, the applicant should evaluate compliance with variance and normality assumptions associated with these tests. If the assumptions are not met (especially with regard to heteroscedastic variances), the applicant should utilize appropriate nonparametric analogs such as the Kruskal-Wallis test. Chi-square tests (or the G-test) are appropriate techniques for analyzing frequencies such as mortalities or shell abnormalities.

The applicant does not propose the analysis of organism tissue samples collected from the outfall vicinities. Due to the limitations of the bioaccumulation studies previously conducted by the applicant (see Part B, Section 6), and the observed high levels of contamination in sediments and organisms in the area, it is recommended that such studies be conducted as part of the biological monitoring program. Fish or invertebrate samples collected during the applicant's demersal fish surveys should be analyzed for toxic substances. Appropriate species would include winter flounder, lobster, and *Mercenaria mercenaria*. Such studies should be coordinated with ongoing analyses of bioaccumulation in the New Bedford area (e.g., Massachusetts Department of Environmental Quality Engineering); however, special emphasis should be given to the collection and analysis of samples near the existing and proposed outfalls. The use of sufficient sampling stations will enable the assessment of concentration gradients in organisms such as *Mercenaria*. With sufficient data the contribution of the New Bedford sewage discharge to the area-wide contamination can be evaluated.

Section 2. Water Quality Monitoring Program

The applicant presents a receiving water monitoring program for both the existing and proposed discharge sites. Monitoring at the proposed site would begin 1 yr before operation of the new outfall. Effluent and influent monitoring is not discussed in detail. The applicant states that effluent monitoring would be done for the same water quality parameters measured in the bay. Appropriate parameters would include BOD_5, dissolved oxygen, total suspended solids, pH, turbidity, and total coliform bacteria.

State Requirements--

Both current and proposed discharges are located in waters designated Class SA by the Commonwealth of Massachusetts Division of Water Pollution Control. This class is designated for the protection and propagation of fish, other aquatic life, and wildlife; for primary and secondary contact recreation; and for shellfish harvesting without depuration in approved areas. For Class SA waters the state of Massachusetts has numerical standards for dissolved oxygen, temperature, pH, and total coliform bacteria and qualitative standards for aesthetics, radioactive and tainting substances, color, turbidity, total suspended solids, oil and grease, nutrients, and other pollutants (Table 35).

No specific state requirements for receiving water monitoring are discussed by the applicant.

TABLE 35. MASSACHUSETTS WATER QUALITY STANDARDS APPLICABLE TO CLASS SA WATERS

A. These minimum criteria are applicable to all waters of the Commonwealth, unless criteria specified for individual classes are more stringent.

	Parameter	Criteria
1.	Aesthetics	All waters shall be free from pollutants in concentrations or combinations that: a) Settle to form objectionable deposits; b) Float as debris, scum or other matter to form nuisances; c) Produce objectionable odor, color, taste or turbidity; or d) Result in the dominance of nuisance species.
2.	Radioactive substances	Shall not exceed the recommended limits of the United States Environmental Protection Agency's National Drinking Water Regulations.
3.	Tainting substances	Shall not be in concentrations or combinations that produce undesirable flavors in the edible portions of aquatic organisms.
4.	Color, turbidity, total suspended solids	Shall not be in concentrations or combinations that would exceed the recommended limits on the most sensitive receiving water use.
5.	Oil and grease	The water surface shall be free from floating oils, grease and petrochemicals, and any concentrations or combinations in the water column or sediments that are aesthetically objectionable or deleterious to the biota are prohibited. For oil and grease of petroleum origin the maximum allowable discharge concentration is 15 mg/l.
6.	Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.

TABLE 35. (Continued)

7.	Other constituents	Waters shall be free from pollutants in concentrations or combinations that: a) Exceed the recommended limits on the most-sensitive receiving water use; b) Injure, are toxic to, or produce adverse physiological or behavioral responses in humans or aquatic life; or c) Exceed site-specific safe exposure levels determined by bioassay using sensitive resident species.

B. *Coastal and Marine Waters* - *the following additional minimum criteria* are applicable to coastal and marine waters.

For Class SA waters:

	Parameter	Criteria
1.	Dissolved oxygen	Shall be a minimum of 6.0 mg/l.
2.	Temperature	None except where the increase will not exceed the recommended limits on the most-sensitive water use.
3.	pH	Shall be in the range of 6.5 - 8.5 standard units and not more than 0.2 units outside of the naturally occurring range.
4.	Total coliform bacteria	Shall not exceed a median value of 70 MPN per 100 ml and not more than 10 percent of the samples shall exceed 230 MPN per 100 ml in any monthly sampling period.

Source: Commonwealth of Massachusetts Water Quality Standards of April, 1978.

Proposed Program--

Station Locations--The applicant proposes monitoring at the 13 stations shown in Figure 29. Stations 1 and 2 are within ZID and near ZID stations, respectively, for the existing outfall site. Stations 5 and 6 are the ZID boundary and near ZID stations for the proposed outfall site. Stations 3 and 7 are reference sites. The depth of water at the reference sites is unknown, but should be the same depth as the outfalls. The reference stations are also further offshore which would minimize effects from other sources. Stations 8 to 13 are intended to detect the effects of runoff on the bay. Effects of the proposed outfall would be monitored only in the near ZID area by the applicant's stations. To detect movement of the waste plume, new stations could be located about 0.9 km (0.5 nmi) from the outfall in the directions of the predominant tidal movement or Stations 10 and 12 could be relocated. Monitoring at Stations 5, 6, and 7 would not begin until 1 yr before operation of the new outfall.

The parameters the applicant intends to measure include dissolved oxygen, total suspended solids (TSS), pH, temperature, salinity, turbidity, and light transmission. Total coliform bacteria is not mentioned by the applicant, but should be added since the state does have an applicable receiving water standard. Since the state also has qualitative standards for color, oil and grease, and nutrients, these parameters should be added. The applicant proposes to use statistical tests (e.g., ANOVA and SNK) to determine if significant differences on a monthly and annual basis exist

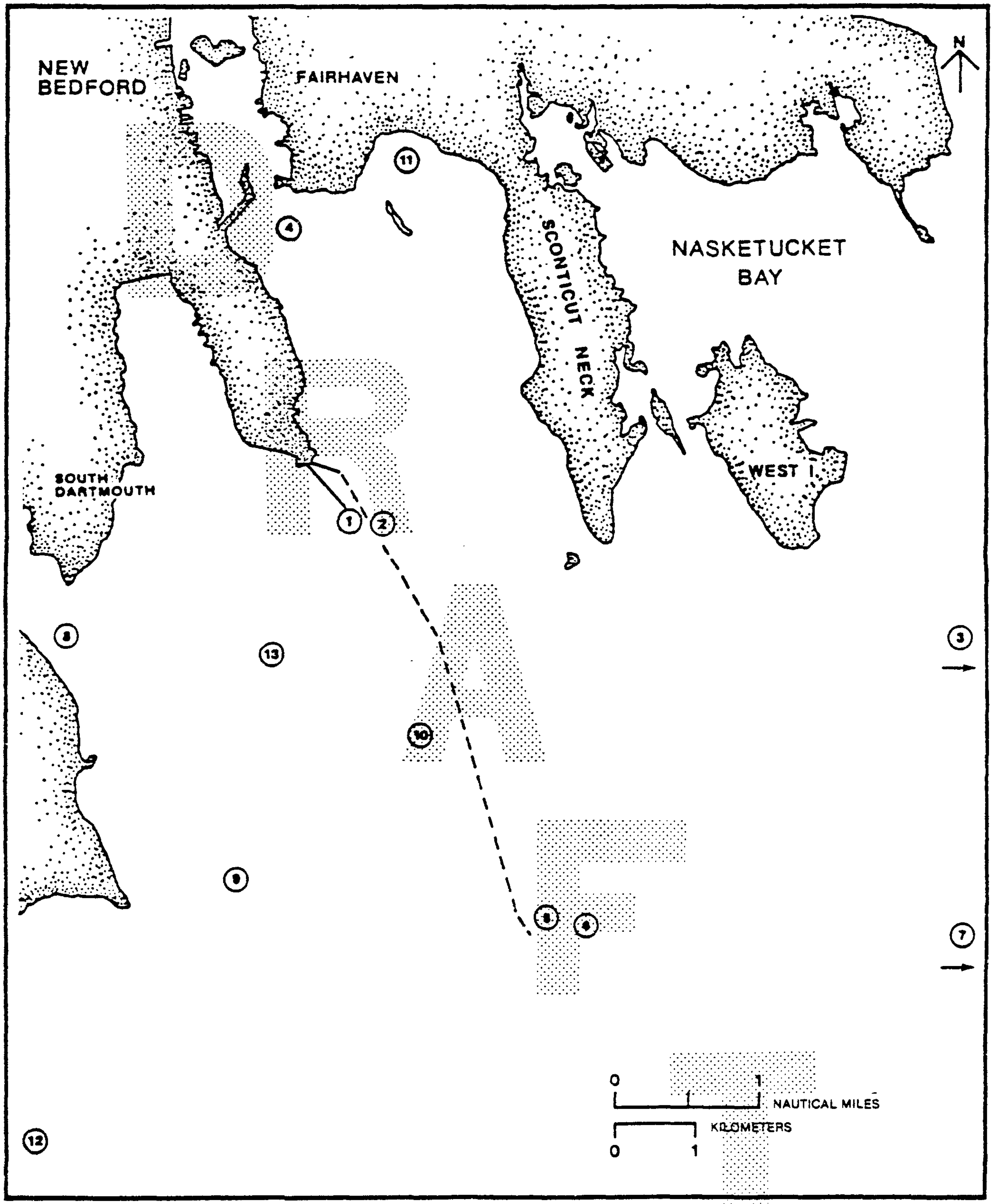

Figure 29. Location of water quality monitoring stations, New Bedford, MA.

between the within-ZID station and the reference stations, and between the near-ZID station and the reference stations. Data at the other stations will also be analyzed for trends.

<u>Sampling and Analytical Methods</u>--The applicant states that dissolved oxygen, temperature, salinity, and pH data would be taken by calibrated probes at 1-m (3-ft) intervals. Details on the kind of probe, the calibration procedures, and the frequency of calibration are not given. Samples for suspended solids and turbidity (measured as JTU) would be collected at top, mid-depth, and bottom with a Van Dorn sampler. Sampling would be done monthly at slack tide when possible for a period of 2 years. The 301(h) regulations specify that monitoring continue for the 5-yr term of the permit, although the sampling frequency could be decreased depending on the results.

The specific analytical procedures used by the applicant are not described except to note that the reference, Standard Methods (APHA 1976), is used. The applicant states that quality control procedures have been written but does not include a copy. A quarterly status report and annual report with conclusions would be prepared by the applicant.

Resources for Implementation--

The applicant does not state whether the monitoring program is to be performed by the applicant or a consultant. Costs for the proposed monitoring program and outfall maintenance for 5 years are listed as

$170,000 in Appendix XXII of the application. No supporting data or cost breakdown data were included.

The wastewater monitoring, as required by the NPDES permit, is done at the New Bedford wastewater treatment plant. No description of monitoring facilities or equipment is included in the application.

Section 3. Toxics Control Monitoring Program

Toxic Quality of the Applicant's Discharge--

Chemical analyses performed on samples of treatment plant effluent detected 57 organic compounds and 13 metals from the list of 129 priority pollutants and 6 pesticides. The samples were 24-h, flow-proportioned composites collected during wet and dry weather conditions.

Concentrations of the following compounds and metals exceeded the available saltwater criteria after initial dilution (dilution factor = 1/60).

	Measured Concentration (ug/l)	After Dilution (ug/l)	Saltwater Criteria (ug/l)
Endosulfan	1	0.017	0.0087
PCB	21	0.35	0.030
Copper	310	5.17	4.0
Mercury	2.6	0.043	0.025
Cyanide	250	4.17	2.0

Asbestos is reported as not being present, although no data are present to confirm that an analysis was performed.

Results of the analyses on wet and dry weather samples are summarized in Part E. Also summarized in Part E are the results of analyses performed on samples from the receiving water, sediments, and animal tissues.

These analyses generally describe conditions in and around the zone of initial dilution (ZID) relative to control stations. Concentrations of several metals in the water column exceeded criteria for the protection of saltwater aquatic life: cadmium, chromium, mercury, selenium, and silver. Cyanide also exceeded its criterion. Concentrations of most metals in sediment samples were notably higher in and near the ZID, relative to the control stations. Tissue samples in and around the ZID contained concentrations of metals similar to the control station, except for nickel which was generally higher in samples from or near the ZID.

The applicant believes that the extensive data presented with the application shows that the New Bedford outfall is not the only source of pollutants. Other sources would include industries that have discharged directly to the bay, as well as ships that may release wastes into bay waters. Some of the direct industiral discharges have reportedly been controlled. The applicant recognizes, however that implementation of a rigorous pretreatment program would significantly reduce the effluent as a contributor of toxic pollutants. Considerable attention should be given, therefore, to toxic control monitoring to follow the progress of industrial pretreatment and other source control programs.

Proposed Sampling Program--

The applicant proposes to collect 24-h flow proportioned composites of treatment plant influent and effluent, yearly, during wet and dry weather conditions. Influent and effluent samples will also be collected during average flow conditions ($\pm$ 10 percent of mean annual flow). Selection of sampling days will be on a random number basis, although the details of the selection process are not explained.

The sampling program will be conducted annually, for a period of three years. The nature of sampling and analysis after the 3 years is not stated.

In addition to the sampling for wet and dry weather, and average flow conditions, the applicant proposes to sample for specific pollutants common to certain industry groups. Both influent and effluent samples will be taken for analysis 10 times per year. The scope of analysis will be limited to pollutants suspected from each industry group, rather than be comprehensive of all priority pollutants.

A form of sampling and analysis not discussed in the application, which may be useful in understanding the character of discharges from industrial areas is to collect samples over several consecutive days and analyze daily for priority pollutants. The scope of analysis should be broad enough to be representative of toxic wastes discharged by industries in the service area. Such analysis could determine the nature and extent of shock loads (sudden, concentrated discharges) of toxic pollutants to the system. Shock loads may not be evident in periodic 1-day analyses, conducted two or three times yearly, since variations in concentrations could be attributable to causes other than shock loads. Sampling and analysis each day for three or four days toward the end of the week would bracket the period when shock loading is more likely to occur.

No details on the sampling process are presented such as the timing of grab samples for volatile organic analysis, sample preservation, and scheduling shipments to analytical laboratories. The extent of involvement of the applicants employees, and those from contract laboratories is not clear either. A standardized approach would help to assure consistency in the collection and handling of samples.

Sample Analysis Program--

The division of anlaytical tasks between the applicant's laboratory and commercial laboratories is not described in the application. If the applicant does not have a complete priority pollutant analytical capability, some of the analysis would probably be assigned to a commercial laboratory. Assigning anaytical tasks to a commercial laboratory is certainly acceptable if the laboratory is familiar with priority pollutant analytical procedures. The applicant should work closely with the selected laboratory to establish effective sample labeling and chain of custody procedures for samples, analytical quality assurance (QA) practices, and reporting formats.

Particular attention should be given to quality assurance data, both in-house and at the commercial laboratory. A quality assurance plan is not presented in the application, however. Such a plan should include the collection and careful analysis of quality assurance data to identify possible errors in procedures, and to evaluate potential inaccuracies caused by interferences or other complications in the analyses. The varied mixture of chemicals in wastewater makes the detection of compounds, at low concentrations, an intricate analytical chemistry problem. Even QA data produced by the commercial laboratory should be collected and reviewed to become familiar with both the practices employed and the results obtained. Quality control testing is the only mechanism available for understanding the value of data on which important monitoring evaluations and program decisions are based.

Data collected by the toxics control monitoring program will be statistically analyzed to determine if concentrations of toxicants received at the plant are reducing. How the data will be managed and interpreted is not discussed in detail. However, since only two or three data sets will be collected yearly, under varying conditions (wet and dry weather and average flow), and since data may be collected for only 3 years, results of the data evaluation could be inconclusive.

Resources for Implementation--

Neither the cost of the toxics control monitoring program nor specific sources of revenue are presented in the application. Consequently, a review of the extent of budget committment to toxics monitoring, and the feasibility for conducting the program is not possible.

PART D

PART D - LETTERS

The applicant has included a copy of a letter from the Massachusetts Division of Water Pollution Control which indicates that a determination of the possible effects of the proposed discharge on other point and nonpoint sources will be made after a thorough review of the application.

PART E

Section 1. Chemical Analysis

Chemical Data Submitted--

Chemical analyses were performed on samples of treatment plant effluent collected under wet and dry weather conditions. Analyses were performed on mixed (homogenous) samples, and on the supernatant of settled samples. Results of analyses on the supernatant were not significantly different from those performed on mixed samples so only the results of the mixed samples are presented in the analyses summary shown in Table 36. The chemical analyses detected 57 organic compounds and 13 metals from the list of 129 priority pollutants and 6 pesticides. Five compounds and metals were measured in concentrations that exceed the available criteria for the protection of saltwater aquatic life. These substances and the concentrations are listed in Part C, Section 3 of this evaluation report.

Also presented with the application are the results of several analyses performed on samples of the receiving water, sediments, and animal tissues. Excerpts from these analyses are presented in Table 37 to summarize the results. The higher of the two concentrations of cadmium, chromium, cyanide, mercury, selenium and silver tabulated for the receiving water exceed the available criteria for seawater (both samples reported were taken in or near the ZID, so it is possible that initial dilution was not complete). High metals concentrations were found in sediment samples in and

TABLE 36. PRIORITY POLLUTANTS DETECTED IN EFFLUENT SAMPLES
(CONCENTRATIONS IN ug/l)

	Priority Pollutants	Wet Weather	Dry Weather
1A	acenaphthene	ND	1
4V	benzene	10	10
6V	carbon tetrachloride	- Not Reported -	
7V	chlorobenzene	10	10
8B	1,2,4-trichlorobenzene	10	ND
11V	1,1,1-trichloroethane	32	17
12B	hexachloroethane	10	ND
13V	1,1-dichloroethane	ND	10
14V	1,1,2-trichloroethane	ND	9
15V	1,1,2,2-tetrachloroethane	ND	10
18B	bis(2-chloroethyl) ether	ND	10
20B	2-chloronaphthalene	ND	1
21A	2,4,6-trichlorophenol	1	1
22A	parachlorometa cresol	1	10
23V	chloroform (trichloromethane)	10	14
24A	2-chlorophenol	10	1
25B	1,2-dichlorobenzene	10	ND
26B	1,3-dichlorobenzene	ND	1
27B	1,4-dichlorobenzene	ND	1
28B	3,3-dichlorobenzidine	1	ND
30V	1,2-trans-dichloroethylene	ND	10
31A	2,4-dichlorophenol	1	1
34A	2,4-dimethylphenol	1	1
38	ethylenzene	10	18
39B	fluoranthene	1	1
43B	bis(2-chloroethoxy) methane	14	20
44V	methylene chloride (dichloromethane)	1	10
48V	dichlorobromomethane	ND	20
51D	chlorodibromomethane	10	16
54B	isophorone	10	24
55B	naphthalene	26	25
57A	2-nitrophenol	ND	1
58A	4-nitrophenol	10	24
59A	2,4-dinitrophenol	ND	20
60A	4,6-dinitro-o-cresol	ND	10
64A	pentachlorophenol	10	10
65A	phenol	10	10
66B	bis(2-ethylhexyl) phthalate	25	25
67B	butyl benzyl phthalate	10	10
68B	di-n-butyl phthalate	10	ND
69B	di-n-octyl phthalate	1	1
70B	diethyl phthalate	10	10
71B	dimethyl phthalate	1	ND
72B	1,2-benzanthracene	1	1

TABLE 36. (Continued)

76B	chrysene	1	1
77B	acenaphthylene	1	1
78B	anthracene	10	10
80B	fluorene	10	10
81B	phenanthrene	10	10
84B	pyrene	1	1
85V	tetrachloroethylene	12	24
86V	toluene	22	32
87V	trichloroethylene	35	25
96P	endosulfan (Beta)	1	ND
107P	PCB-1254 (Arochlor 1254)	10	ND
109P	PCB-1232 (Arochlor 1232)	ND	9.3
112P	PCB-1016 (Arochlor 1016)	11	ND
	Metals (total):		
114M	Antimony	30	730
115M	Arsenic	30	30
116	Asbestos (fibrous)	ND	ND
117M	Beryllium	3	85
118M	Cadmium	130	150
119M	Chromium	420	170
120M	Copper	310	130
121	Cyanide (total)	250	160
122M	Lead	110	60
123M	Mercury	2.6	0.4
124M	Nickel	200	52
125M	Selenium	56	30
126M	Silver	9	9
127M	Thallium	40	40
128M	Zinc	380	21

ND = Not Detected.

TABLE 37. SELECTED RESULTS OF CHEMICAL ANALYSES OF SAMPLES FROM THE WATER COLUMN, SEDIMENT, AND ANIMAL TISSUES

		Marine Water (ug/l)		Sediment (mg/kg-dry)			Tissue (mg/kg-wet)		
		Station 1	Station 2	ZID	Beyond ZID	Control	ZID	Beyond ZID	Control
66B	bis (2-ethylhexyl) phthalate	20	ND	ND	NR	NR	ND	NR	NR
67B	butyl benzyl phthalate	ND	ND	ND	NR	NR	4	NR	NR
68B	di-n-butyl phthalate	ND	ND	1.7	NR	NR	ND	NR	NR
70B	diethyl phthalate	ND	ND	0.3	NR	NR	ND	NR	NR
84B	pyrene	6	ND	ND	NR	NR	0.001	NR	NR
107P	PCB-1254	0.05	0.5	8.75	27	NR	0.001	NR	NR
114M	antimony	60	60	3.25	9	9	0.7	0.7	0.7
115M	arsenic	80	120	6.9	3.6 to 14.5	10.5 to 13.5	4.0	2.5 to 3.6	3.9
117M	beryllium	5	5	0.055	0.1 to 0.5	0.65 to 0.72	0.20	0.05 to 1.5	1.5
118M	cadmium	50	30	25	0.3 to 57	0.16 to 0.44	0.20	0.04 to 0.5	0.5
119M	chromium	40	30	210	10.5 to 515	31.5 to 51	3.25	1.2 to 4.2	2.9
120M	copper	3	3	705	21 to 895	17 to 31.5	1.85	0.2 to 1.8	1.3
121	cyanide	33	7	---	---	---	---	---	---
122M	lead	10	10	750	13 to 715	7.2 to 48.5	0.11	0.11	0.16
123M	mercury	0.36	0.02	0.15	0.15 to 0.48	0.016 to 0.034	0.01	0.01 to 0.08	0.02
124M	nickel	NR	NR	9.95	3.55 to 46.5	7.75 to 8.70	4.35	0.21 to 8.6	1.4
125M	selenium	70	70	8	8	8	2	2	2
126M	silver	6	6	0.27	0.26 to 0.77	0.38 to 0.60	0.1	0.07 to 0.43	0.17
127M	thallium	1	1	0.9	0.9	0.9	0.07	0.07	0.07
128M	zinc	1	1	550	25 to 995	34 to 51	11.5	1 to 20	13.5

ND = Not Detected; NR = Not Reported.

in proximity of the ZID, relative to a control station, as shown in the table. Concentrations in animal tissues in and near the ZID were not much different, however, than control samples (with the possible exception of nickel). (The reader should be alerted that the units used in tables and text in the original application appeared to interchange "ppm" with "ppb." An attempt was made to reconcile this apparent error in Table 37.)

Procedures involved in sample collection and analysis are discussed in the application, along with citations to EPA procedures and analytical protocol. Based on the discussion it is reasonable to conclude that results of the analyses afford a reasonably accurate characterization of the effluent and the affected environment. If future data are also produced with care, an adequate statistical base will be available to chart the effects of pretreatment and source control efforts. It would have been useful to have had the results of specific quality assurance tests performed during the reported analyses. The only QA data presented with the application is a generalized long term statistical summary of QA tests.

Toxic Pollutant and Pesticide Sources--

Potential sources of the identified toxics are not presented or discussed in the application. A copy of the industrial source inventory is not included either, so it is not possible to study the types of industries that discharge to the sewer system.

Section 2. Industrial Pretreatment Program

Program Compliance--

Authority--A letter from the City Solicitor for the city of New Bedford is included in the application. The letter cites three areas of Massachusetts General Laws that give the city of New Bedford authority to:

1. Enact ordinances

2. Impose fines

3. Sue to enforce its ordinances.

While this statement addresses, in general, the authorities required by 40 CFR 403.8(f), a more specific legal analysis is needed to address adequately the six points of authority identified by the regulations as follows:

1. Deny or condition the contribution of pollutants from industrial users

2. Require compliance with pretreatment standards

3. Control the contribution of polluants from industries by permit or other means

4. Require compliance schedules and monitoring reports

5. Carry out inspection, surveillance, and monitoring

6. Obtain remedies from noncompliance.

Included with the application is a copy of New Bedford's sewer use ordinance which is the legal mechanism for implementing industrial pretreatment. A review of this ordinance indicates that the applicant does have a measure of authority in each of the areas listed above. There is some question, however, whether the applicant can employ permit controls on industries since there is no mention of an industrial permit procedure in the ordinance. Also, remedies for noncompliance appear to be limited to rejecting the waste or imposing fines in an amount not to exceed $20 per day. The process for rejection (e.g., suspend service) is not specified and it appears that the fine can only be imposed after a court procedure that may be lengthy. Legal counsel should, therefore, review the ordinance for specific compliance with the authority and procedure requirements of 40 CFR 403.8 (f)(1) and (2).

<u>Administration</u>--The city of New Bedford will establish within the Sewer Department a position for an industrial waste manager. This individual will have a large number of responsibilities including:

1. Controlling industrial waste discharges throughout the system.

2. Receiving and evaluating all applications for discharge of industrial waste to the system.

3. Notifying industries of categorical discharge limits.

4. Receiving and analyzing compliance reports from industries.

5. Visiting and inspecting industrial facilities, including sampling and compliance monitoring.

6. Surveying new industries.

7. Liaison with other utilities.

8. Developing procedures for tracking down violators.

For a service area that is an "industrial community," assigning the above-listed duties to one person would probably result in a severe overcommittment of the individual.

The applicant says the industrial waste manager would have clerical support and assistance from laboratory and sewer maintenance personnel for sampling and analysis throughout the system. An assistant would be hired, according to the applicant, if one person is inadequate to carry out the duties. The number of industries in the service area is not described in the application, but an industrialized area with an average sewer flow of 30 MGD could require several professional and technical personnel to adequately design, implement, and operate an effective industrial pretreatment program.

Funding--A budget for the industrial pretreatment program has not been established, according to the applicant, because the program has not been developed. The city will apply for a grant under the Clean Water Act to finance implementation of the program. Details of the grant application were to have been completed and submitted to EPA in 1979. A plan of study for the program has been submitted to EPA (according to Mr. Steve Silva, EPA Region 1), and the grant application has been approved. Grant funds are to be released in July, 1981.

Industrial Source Inventory--

The applicant completed a survey of industries in 1974 and was completing another survey at the time the application was submitted. The application is not clear as to the number of industries in the service area, or what information was collected from the industries surveyed. Approximately 300 questionnaires were sent to known industrial and commercial users in the most recent survey. Whether this represented the totality of industries in the service area or just the largest users is not stated.

There is no discussion of the form and contents of the inventory estabished by the two surveys, or methods for keeping the inventory current.

Maintaining a complete inventory of sources is fundamental to the control of industrial discharges, and is necessary for the source notification aspect of pretreatment program implementation. The inventory should include information on the type of activity conducted on site, character of the waste (compounds and quantities), materials that may accidentally be released to the waste stream, results of self monitoring and city monitoring efforts, histories of accidents or noncompliance, the nature of permits or agreements affecting wastewater discharge, and other information useful in conducting the program.

Industrial Compliance Reviews--

The industrial waste manager will have responsibility for industrial compliance reviews. No details on procedures for conducting such reviews are presented in the application. Presumably such procedures would be established as part of the industrial pretreatment program development.

Program Compliance Schedule--

The applicant plans to complete the following tasks within 18 months following issuance of a 301(h) modified NPDES permit:

Task	Months
Industrial waste survey	0-6
Discharge limitation development	5-12
Monitor/enforcement program	6-18
Legal basis	3-6
Construction/equipment needs	12-18
Funding	7-10
Public participation	2,8,18

The scheduling may be achievable if adequate resources are committed to each task. As mentioned earlier, the industrial waste manager will probably require assistance to perform his job adequately, particularly if he is to have an active part in each of the above-listed tasks.

Conditional Acceptance Provisions--

The applicant does not request conditional acceptance of the pretreatment program.

Section 3. Nonindustrial Source Control Program

Source Identification Schedule--

The applicant proposes, in general terms, to look for sources of pollutants not attributable to industrial sources. The search will be conducted during, and for 6 months following, development of the industrial pretreatment program. A plan for removal of pollutants having nonindustiral sources will be implemented, if feasible, but no details are given.

Also proposed is an in-system sampling analysis program to determine if particular regions of the service area contribute more toxic pollutants than others. Action to control the pollutants at their source will than be considered. No details are presented on this aspect of the program.

Source Control Determination Schedule--

No details on procedures or approaches to nonindustrial source control are provided.

Program Development and Implementation Schedule--

Analyses to determine the extent of nonindustrial contributions to the waste stream will parallel development of the industrial pretreatment program. No further schedule for development of a nonindustrial source control program is provided.

Resource Support Schedule--

Financial and personnel resources available for nonindustrial source control are not presented.

PART F

efficiencies. Projected effluent mass emissions for 1986 (when the improvements are expected to be completed) and 1990 are estimated below.

	1986	1990
Flow	1.23 m^3/sec	1.35 m^3/sec
	(28.1 MGD)	(30.8 MGD)
Biochemical oxygen demand	10,660 kg/day	12,025 kg/day
	(23,500 lb/day)	(26,500 lb/day)
Suspended solids	5,500 kg/day	6,175 kg/day
	(12,100 lb/day)	(13,600 lb/day)

Combined Sewer Overflow Control Schedule--

The city of New Bedford has a total of 30 combined sewer overflows in its system. Past efforts to minimize overflows are discussed by the applicant, along with proposed future efforts. The city has a program to maintain, clean, and repair weirs and regulating devices to limit overflows. Some modifications to existing pump stations, involving replacement of worn and obsolete equipment and increasing pump capacity, have been completed to eliminate pump station storm-related wastewater overflows. Further pump station modifications have been designed and are awaiting approval of this application. Separation of the sewerage system in several areas of New Bedford has been designed and is ready for bidding and construction. A proposed study will determine volume, frequency, and quality of storm-related overflows discharged to watercourses and provide recommendations for improvements based on the findings.

PART F - EFFLUENT VOLUME AND MASS EMISSIONS

Project Effluent Volume and Mass Emissions--

The applicant presents projections for wastewater flows, BOD, and suspended solids for the period 1980 through 2020. No particular 5-year period is discussed because of the currently unknown date for such a period to begin. Average wastewater flows are projected to increase from the 1980 level of 1.05 m^3/sec (24 MGD) at a rate of 0.03 m^3/sec (0.68 MGD) per year. Projected peak flows are expected to decrease at a rate of 0.028 m^3/sec (0.65 MGD) based on the applicant's assumption that some major combined sewers would be separated. The basis for the projections (e.g., per capita contribution and service area population projections) are not provided nor are there any means identified which assure that excessive flows will not occur.

Influent and effluent levels for BOD and suspended solids are presented by the applicant. Since the existing data on removal efficiencies at the treatment plant are not indicative of a properly operating primary facility, projected removal efficiencies were used to determine the effluent loadings based on a 30-percent BOD removal and 50-percent suspended solids removal. These are the minimum removal rates expected once the proposed improvements to the existing primary treatment plant are completed in 1986. The applicant presents projected influent loadings based on projected flows and concentrations but does not present effluent mass emissions. These can be determined from the influent loadings and the estimated minimum removal

PART G

PART G - USE OF TITLE II FUNDS

The city of New Bedford has a currently active Step 1 grant to update facilities planning work presented in a 1974 report. Table 38 is a summary of the scope of the planning effort and projected completion dates. According to the applicant, much work is necessary to complete the Step 1 facilities plan, and a grant addendum would have to be requested to complete a plan based on EPA's current requirements and the 301(h) application (primarily pretreatment and nonindustrial source programs).

The applicant presents preliminary cost information comparing secondary treatment with less-than-secondary treatment (Table 39). The applicant states that it is unreasonable to revise the preliminary cost analysis (based on September, 1979, prices) because of the uncertainty surrounding the timing of 301(h) approval.

TABLE 38. PROJECTED PLANNING EFFORT

New Bedford Facilities Plan Scope of Work/Tasks	Completion Status
1. Infiltration/Inflow Analysis	Started March 20, 1978. Draft report to be submitted to City in Fall of 1979.
2. Environmental Assessment statement and Public Participation as required by February 16, 1979, Federal Register	Started March 26, 1979, and deals primarily with secondary treatment facilities and sludge disposal solutions within New Bedford's boundaries. The EAS cannot be realistically completed until pilot plant testing is complete and the rest of the report is complete in June, 1980.
a. Second official advertised Public Meeting on Facilities Plan	September 11, 1979 (Note: First kick-off public meeting was held June 11, 1979, and received poor attendance.).
b. Third Public Meeting on Facilities Plan	Estimated to be in April, 1980.
c. Official Advertised Final Public Hearing	Estimated to be in June, 1980.
3. Phase I - Wastewater Treatment Facilities Evaluation (i.e., Improvements to primary treatment system)	Field work is complete. Draft report to be available by September 13, 1979.
4. Phase II - Existing Plant Treatability Testing	Conclusion is that one pilot plant will employ activated sludge/chemical coagulation process.
5. Phase III - Industrial Waste Survey	Currently underway and to be completed June, 1980.
6. Phase IV - Pilot Plant Studies of Secondary Treatment Process	Pilot plant is to be operational in September, 1979. Field work to be complete in March, 1980, and final report complete in June, 1980.
7. Phase V - Wastewater/Septage Treatment Disposal Alternatives	Draft to be submitted in June, 1980.
8. Phase VI - Alternative Investigations	Pending results of Pilot Plant studies.
9. Phase VII - Final Cost Effective Analysis of Alternatives	Pending results of Pilot Plant studies. Final analysis to be completed by June, 1980, Hearing.
10. Phase VIII - Facilities Planning Report Finalization. Recommended plan, implementation schedule for construction, cost to homeowner, etc. to be presented at final Public Hearing.	June, 1980.
11. Combined Sewer Overflow (CSO) Study	Not currently under contract but schedule to be complete in June, 1981.

TABLE 39. PRELIMINARY COST EFFECTIVENESS ANALYSIS OF PRIMARY VS. SECONDARY TREATMENT*

Alternatives	(1) (2) (3) Initial Capital Cost	(4) Present Worth of Initial Capital Cost	(5) Average Annual O&M Cost	Present Worth of Average Annual O&M Cost	(6) Average Annual Montoring Cost And Outfall O&M (five years)	Present Worth of Average Annual Monitoring Cost (five years)	Present Worth o Total Co
LOW RANGE ANALYSIS							
Secondary Treatment (Existing Outfall)	$44,000	$40,500	$3,000	$32,000	$ --	$ --	$72,500
Section 301(h) Improved Discharge w/ Primary Treatment*	32,000	27,200	1,500	16,000	170	700	43,900
HIGH RANGE ANALYSIS							
Secondary Treatment	$48,000	$44,200	$3,000	$32,000	$ --	$ --	$76,200
Section 301(h) Improved Dishcharge w/ Primary Treatment*	57,000	48,200	1,500	16,000	170	700	64,900

(1) Total Project Costs - Note: City's Share = 10%

(2) Capital Costs include: Preliminary estimates of Contractor's bid price, surveys, borings, etc., and an allowance for engineering and contingencies.

(3) Capital Costs are September 1979 costs estimates.

(4) Interest rate = 6-7/8%, 20 year planning period. Based on 50 year structural life and 20 year equipment life.

(5) Preliminary Operation and Maintenance Costs based upon generalized cost curves and September 1979 prices. Additional power cost for longer outfall is assumed negligible.

(6) Monitoring costs are based on CDM's interpretation of the final Section 301(h) regulations

NOTE: All costs presented are based on September 1979 preliminary costs and would have to be updated during facilities plan. City must fund 100% of O&M and monitoring costs.

*Improved Discharge includes 22,000 ft. outfall/diffuser & Effluent Pumping Station. Improvements to Primary Plant are not included in this table.

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